

Regional Engagement Workshop Summary Report: U.S. Caribbean Region

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Introduction

The Fourth National Climate Assessment (NCA4), currently in development, will assess the science of climate change and its impacts across the United States. It will document climate change-related impacts and responses for various sectors and regions, with the goal of better informing public and private decision-making at all levels.

To ensure that the assessment is informed by and useful to stakeholders, engagement workshops were planned for each of the 10 NCA4 regions. These workshops provided stakeholders an opportunity to provide input to and exchange ideas with the chapter author team on key message formulation, share relevant resources, and give feedback on issues of importance to their region.

Workshop Structure

In an effort to maximize participation while easing the travel burden, organizers employed a ‘Hub and Satellite’ model for NCA4 Regional Engagement Workshops. A hub—or primary location—hosted stakeholders, the chapter author team, and NCA4 staff from the U.S. Global Change Research Program (USGCRP). Satellite locations throughout the region established remote connections to the hub for plenary presentations and discussion. Satellites were encouraged to hold break-out sessions on regional concerns and proposed topics for NCA4, reporting their discussions to the hub at a pre-determined time.

The U.S. Caribbean Regional Engagement Workshop

On March 9, 2017, the NCA4 U.S. Caribbean chapter team held a Regional Engagement Workshop. The objectives of the workshop were to gather input from a diverse array of stakeholders throughout the U.S. Caribbean region to help inform the writing and development of NCA4, and to raise awareness of the process and timeline for developing the report. For the NCA4, the U.S. Caribbean region is defined to include Puerto Rico and the U.S. Virgin Islands.

The U.S. Forest Service’s International Institute of Tropical Forestry (USFS IITF), in San Juan, Puerto Rico (PR), served as the hub location. Two satellite locations were used at St. Thomas, U.S. Virgin Islands (USVI) and Raleigh, North Carolina (Figure 1). Participants also joined the meeting virtually.

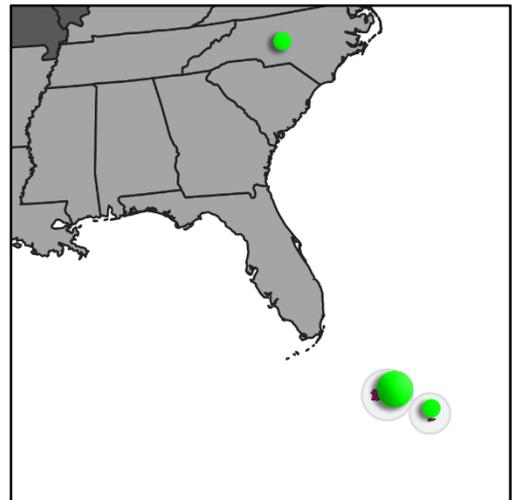


Figure 1. Map of the U.S. Caribbean REW hub & satellite locations: San Juan, Puerto Rico; St. Thomas, U.S. Virgin Islands; Raleigh, North Carolina.

Authors, Locations, and Staff

Authors

- William Gould, USFS IITF (Coordinating Lead Author)
- Ernesto Diaz, Dept. Recursos Naturales y Ambiente, Puerto Rico (Regional Chapter Lead)
- Wayne Archibald, Archibald Energy Group
- Felix Aponte-González, Aponte, Aponte & Asociados
- Jared Bowden, University of North Carolina at Chapel Hill
- Lisamarie Carruba, National Oceanic and Atmospheric Administration (NOAA)
- Wanda Crespo, Estudios Técnicos
- Grizelle Gonzalez, USFS IITF
- Annmarie Goulbourne, Environmental Solutions Ltd
- Eric Harmsen, University of Puerto Rico (UPR)
- Azad Henareh, Colorado State University
- Odalys Martínez-Sánchez, NOAA
- Kathleen McGinley, USFS IITF
- Melissa Meléndez, University of New Hampshire
- Pablo Méndez, UPR
- Aurelio Mercado, UPR
- Julio Morell, UPR
- Roger Pulwarty, NOAA
- Adam Terando, U.S. Geological Survey

Satellite & Hub Hosts

- USFS International Institute for Tropical Forestry (San Juan, PR)
- University of the Virgin Islands, GeoCAS Institute (St. Thomas, USVI)
- DOI Southeast Climate Science Center (Raleigh, NC)

USGCRP Staff

- Chris Avery
- Apurva Dave

Overview and Topics of Discussion

Bill Gould, Coordinating Lead Author (CLA), and Ernesto Diaz, Regional Chapter Lead (CL), opened the workshop with a welcome to all participants. Apurva Dave, USGCRP Senior Analyst and International Coordinator, gave an overview of the NCA, providing context and explaining the goals of the workshop.

Gould then introduced the U.S. Caribbean chapter itself, including a notional outline. From there, individual author team members went into greater detail on the chapter components, including the proposed focal areas for Key Messages:

- Observations – Odalys Martinez
- Climate projections – Adam Terando
- (*Focal Area 1*): Freshwater availability – Eric Harmsen
- (*Focal Area 2*): Changing oceans – Julio Morell
- (*Focal Area 3*): Warming temperatures – Pablo Mendez
- (*Focal Area 4*): Rising sea levels and coastal erosion – Aurelio Mercado
- (*Focal Area 5*): Extreme events – Félix Aponte-González
- (*Perspective*): US Virgin Islands Perspective – Wayne Archibald
- (*Perspective*): International Perspective – Roger Pulwarty

In an open question-and-answer session to end the morning, stakeholders were invited to provide comment to the author team and USGCRP staff on the report development process, as well as the substance of the U.S. Caribbean chapter. Stakeholders were also given the opportunity to share thoughts on areas that were not covered by the previously-identified focal areas.

During the afternoon, participants shared specific questions, issues, ideas, resources, and case studies for each of the aforementioned focal areas. Stakeholders were asked a specific series of questions around which to structure their responses:

1. How is or how has climate change affected this topic (i.e., observed change)?
 - Are there specific case studies you would suggest to illustrate that observed change?
2. How is climate change projected to affect this topic in the next 20-30 years and at the end of the century (i.e., projected change)?
 - Are there specific case studies you would suggest to illustrate that projected change?
3. What challenges, opportunities, and success stories for addressing risk can be highlighted?
 - Are there specific case studies you would suggest to illustrate those challenges, opportunities, and success stories?
4. What are the emerging issues and/or research gaps on this topic?
 - Are there specific case studies you would suggest to illustrate those emerging challenges or research gaps?

A copy of the full meeting agenda is provided in Appendix A.

Key Takeaways

Stakeholders identified areas of opportunity and concern, case studies, and relevant regional information associated with each of the focal areas. This feedback was later distilled into key thematic takeaways for the chapter author team. These takeaways are summarized below.

Freshwater Availability

- Examine impacts of trends in freshwater usage, precipitation changes, extreme events on water reserves (including increases in solids and salinity). More data are needed on evapotranspiration.

- Explore overall freshwater usage and distribution of freshwater across the general population (considering recent government actions to preserve freshwater resources and access to freshwater, e.g., the Bosque Modelo Initiative in PR).
- Investigate impacts of/effects on agriculture (with drip irrigation as an example of managing consumption). Consider using local farmers as a knowledge resource for observations of precipitation variability and water availability.
- Consider other impacts of water availability, including differential impacts on species (e.g., some organisms will thrive on less water) and new landscapes (e.g., new beaches due to drought).
- Possible adaptation/response strategies to highlight include permeable asphalt, public education programs, implementing water collection systems (as in USVI), and construction codes for houses to be designed with water holding capacity (also in USVI).

Changing Oceans

- Overall, low participation in the group potentially reflected a lack of experts, or lack of proper framing. This could be an important consideration for authors when the team considers potential research gaps and emerging issues.
- This section may overlap with other sections (e.g., sea level rise, extreme events). The chapter should also consider the general sparseness of ocean data.
- Consider that changes in marine species abundance distributions are the result of complex interactions distributed in space and time between the organisms and their environment, with compounding stressors acting everywhere. Adaptive responses may also be protecting species from current changes (e.g., shellfish secreting thicker shells in response to higher acidity).
- For coral reef communities, acknowledge the lack of understanding of sedimentation and pollution effects on corals (e.g., sensitivity to changes in sediment deposition- the amount of sedimentation discharged into coastal waters during one month of enhanced rainfall vs. during a one-day extreme event).

Warming Temperatures

- Examine impacts on agriculture/wildlife. Changes in the planting seasons can affect the production schedule and subsequently impact the market through price changes. There are also stresses on livestock, increased demand for pesticides to control pests, damage to the soil health and productivity. With respect to wildlife, consider effects on biodiversity (e.g., coquis in PR) and sensitivity of ecosystems to a 1-2-degree Celsius increase.
- Explore impacts on tourism: overall decreases in tourism, with regional shifts (e.g., in PR, rising temperatures in the east could impact arrival of tourists on the coast).
- Consider threats to public health: effects on people with respiratory diseases, cardiovascular diseases, and increased cases of asthma due to high use of agrochemicals. Increased energy demand can have an impact on air pollution. Impact to aging populations by heat, increased use of central air conditioning, new frontiers for vector diseases.
- Investigate impacts on infrastructure: increase in the cost of operations due to the increase in the cost of energy, which implies an increase in the cost of operations in hospitals, to store food, etc.
- Possible adaptation/response strategies to highlight include planting heat-tolerant species, developing heat early warning systems, shade coffee techniques to reduce the impact of high temperatures. Acknowledge that uncertainty is one of the biggest challenges for adaptation.

- Challenges to adaptation/response include vulnerability of low-income populations, lack of cooperation between government agencies, need for infrastructure studies, and public education on impacts.

Rising Sea Levels and Coastal Erosion

- Effects being observed now include faster acceleration of sea level rise, changes of vegetation in mangroves, saline intrusion, impacts on tourism and coastal infrastructure.
- Projected impacts include higher salinity of aquifers, coastal flooding, displacement of coastal communities, changes in quality of life due to loss of recreation opportunities, beach environments, airport flooding, enhanced impacts of cyclonic tides, flooding due to loss of percolation capacity.
- Possible adaptation/response strategies to highlight include development of a coastal vulnerability index, the community of Juana Matos having ecosystem-based adaptations to avoid coastal flooding.

Extreme Events

- Consider a broad range of impacts including:
 - droughts and floods on tourism activities;
 - wind effects on the electrical infrastructure;
 - droughts and tropical cyclones on wildlife (e.g., shifting of the area of habitat for species like the elfin warbler during the last drought); and
 - flooding on disease transmission (e.g., Zika).
- Consider the added stress of projected impacts to the insurance sector. People will have to get insurance to cover for losses from extreme events. A business-as-usual approach will result in higher costs across sectors.
- Possible adaptation/response strategies to highlight include use of Senepol cattle during the drought, which are more resistant to high temperatures.
- Opportunities for improving adaptation/response include understanding the role of gender in response and risk management, and incorporating traditional knowledge on how to deal with climate change.
- Challenges to adaptation/response include incorporating a multi-hazard approach (e.g., preparing for/responding to a drought that comes after a storm or heavy rains).

U.S. Virgin Islands

- Evaluate local impacts rather than regional impacts to capture the microclimates.
- Assess PR and the USVI distinctly where possible, be sensitive to geographic and cultural differences, try to address the uniqueness of the USVI (separate climate fact sheets for PR and the USVI would be helpful).
- Unique elements of a USVI assessment include lack of freshwater reservoirs, impacts of migration, the shipping industry, and food delivery.
- Areas of particular interest include changing weather patterns on human health (e.g., dependence on household cisterns that are promoting mosquito-borne diseases), impacts on tourism infrastructure and the building industry.
- Challenges to adaptation/response include lack of long-term data sets and information gaps on crop yields.

Raleigh, North Carolina

- On the Freshwater Availability focal area:
 - Consider factors such as drought effects on reservoirs, storage and supplies, regime shifts after significant droughts (e.g., where non-natives can outcompete native species).
 - Address the first-order changes expected - a decrease in mean precipitation and increase in extreme precipitation in the Southeast/ subtropics, and opposing trends in subtropical regions (drier) and tropical regions (more rain).
 - Potential case studies could include a study of faunal resilience to extreme events.
 - Possible adaptation/response strategies to highlight include Natural Resources Conservation Service programs and drought resistance strains for tropical crops.
- On the Warming Temperatures focal area:
 - Consider differential warming during the day (higher in the mountains than in the lowlands), and projected differences in island interior vs. coastal temperature trends.
 - Potential case studies could address the impacts on coffee production, pest damage, and/or food security.

Results

The feedback provided during this workshop serves as valuable input to the development of not only the U.S. Caribbean chapter of NCA4, but of all chapters. This summary report is being shared with all NCA4 authors to inform the development of their chapters. It will also be made publicly available on the NCA4 website (www.globalchange.gov/nca4). Over 50 stakeholders throughout the U.S. Caribbean region participated in the day-long virtual meeting, providing authors with a great deal of useful feedback – from concerns they face, to resources they use and specific case studies where communities are working to address the risks they face as a result of climate change. Responses from both authors and participants indicated that the workshop was not only positively received in and of itself, but it served to cultivate new relationships, research ideas and, hopefully, future collaborations across the U.S. Caribbean.

About the NCA

The National Climate Assessment is the U.S. Government's premier resource for articulating the risks posed to the Nation by climate change, as well as what is being and can be done to minimize those risks. It is an inter-agency effort, bringing together experts from the 13 Federal agencies of USGCRP, the broader Federal government, as well as hundreds of experts in the academic, non-profit, and private sectors.

Appendix A: Workshop Agenda



Caribbean Regional Chapter - Stakeholder Engagement Workshop
Fourth National Climate Assessment (NCA4)
March 09, 2017 in San Juan, Puerto Rico
OPEN TO THE PUBLIC



DRAFT AGENDA - Thursday, March 9, 2017

Objective: To gather input from a diverse array of stakeholders throughout the region to inform the Caribbean chapter of NCA4, and to share the process and timeline for the development of NCA4.

- **Main Location:** Conference Room - [International Institute of Tropical Forestry in San Juan](#)
- **Satellite Locations:**
 - U.S. Virgin Islands: UVI St. Thomas Campus: GeoCAS Institute, 2nd Floor, room 212
Contact: Kostas Alexandridis geocas@uvi.edu
 - Raleigh, North Carolina State University: 123 David Clark Labs, 100 Brooks Ave
Contact: Adam Terando aterando@usgs.gov
 - Washington, DC: 1800 G Street, NW, Suite 9100
Contact: Apurva Dave adave@usgcrp.gov

Organizers: USDA Caribbean Climate Hub, Puerto Rico Department of Environmental and Natural Resources, University of the Virgin Islands, USGS SE Climate Science Center, and the U.S. Global Change Research Program.

Remote Connection via Adobe Connect: To join the meeting on March 9, 2017 go to:

- https://usfs.adobeconnect.com/climate_hub/
- Audio via computer or Call-in by phone: USA Toll-Free: 888-844-9904, Access Code: 7518378

AGENDA

9:00 Registration opens

9:30 Welcome, Workshop goals and brief introductions Ernesto Diaz, William Gould

9:45 Overview of the National Climate Assessment and NCA4 Apurva Dave/Chris Avery

- U.S. Global Change Research Program
- Mandate, timeline, and structure of NCA4
- Ways to get involved
- Areas of desired input from public comments
- Questions and Answers

10:15 Caribbean Chapter Outline William Gould, Ernesto Diaz

10:30 Presentation of chapter components

1. Observations – Odalys Martinez
2. Climate projections – Adam Terando (*remote*)

Five key messages

3. Freshwater availability – Eric Harmsen
4. Changing oceans – Julio Morell (*remote*)
5. Warming temperatures – Pablo Mendez

6. Rising sea levels and coastal erosion – Aurelio Mercado
7. Extreme events – Félix Aponte-González

Perspectives

8. US Virgin Islands – Wayne Archibald
9. International – Roger Pulwarty

11:30 Stakeholder Perspectives

- Seeking input on:
 - Are we capturing key attributes, assets and things of greatest value?
 - Are those things vulnerable to or at risk from climate change?
 - What type of information will be useful for their industry? (per sector)
 - What is missing from the outline chapter?
 - If there was a final report, what would you want to get out of it? (datasets, etc)

11:55 Instructions for afternoon exercise

12:00 LUNCH - provided

1:00 Breakout Groups based on the 5 topics of the key message

- *(Participants will rotate to visit 2-3 groups)* Seeking input on:
 - How is or has climate change affected this topic (i.e., observed change)?
 - How is climate change projected to affect this topic in the next 20-30 years and at the end of the century (i.e., projected change)?
 - Are there resources (reports, studies, etc.) or case studies we should be aware of?
 - What challenges, opportunities and success stories for addressing risk can be highlighted?
 - Are there case studies or specific resources to highlight?
 - What are the emerging issues and/or research gaps on this topic?
- *Freshwater availability* Facilitator: Eric Hamsen
- *Changing oceans* Facilitator: TBA
- *Warming temperatures* Facilitator: Pablo Mendez
- *Rising sea levels and coastal erosion* Facilitator: Aurelio Mercado
- *Extreme events* Facilitator: Felix Aponte
- *Satellite site NCSU* Facilitator: Adam Terando
- *Satellite site UVI* Facilitator: Kostas Alexandridis

2:15 BREAK

2:30 REPORT Back from Breakout Groups *(10 minutes per group)*

3:45 Concluding remarks and next steps

4:00 END of meeting



United States Department of Agriculture
Caribbean Climate Hub



U.S. Global Change
Research Program

Appendix B: List of U.S. Caribbean Regional Chapter Authors

Coordinating Lead Author: William Gould, United States Forest Service

Chapter Lead: Ernesto Diaz, Puerto Rico Department of Natural Resources and Environment (DRNA)

Authors:

- Wayne Archibald (Archibald Energy Group)
- Felix Aponte-González (Aponte, Aponte & Asociados)
- Jared Bowden (UNC-CH, CEMPD/Inst for Environment)
- Lisamarie Carruba (NOAA Fisheries)
- Wanda Crespo (Estudios Técnicos)
- Grizelle Gonzalez (USFS International Institute of Tropical Forestry)
- Annmarie Goulbourne (Environmental Solutions Ltd)
- Erik Harmsen (University of Puerto Rico, Department Agriculture & Biosystems Engineering)
- Azad Henareh (Colorado State University)
- Odalys Martínez-Sánchez (NOAA)
- Kathleen McGinley (USFS International Institute of Tropical Forestry)
- Melissa Meléndez. (University of New Hampshire School Marine Science and Ocean Engineering)
- Pablo Méndez (University of Puerto Rico, School Public Health & Dept Environmental Health)
- Aurelio Mercado (University of Puerto Rico, Department Marine Science)
- Julio Morell (University of Puerto Rico, CARICOOS)
- Roger Pulwarty (NOAA Climate Program and Earth System Research Laboratory)
- Adam Terando (USGS Southeast Climate Science Center, NC State University)

USGCRP staff:

- Chris Avery (Senior NCA Manager)
- Apurva Dave (U.S. Caribbean POC)

Coordination and Logistic Support:

- Isabel Pares, Lead Coordinator (USFS, International Institute for Tropical Forestry)
- Kostas Alexandridis (University of the Virgin Islands)
- Nora Alvarez (USFS, International Institute for Tropical Forestry)
- Jessica Castro (USFS, International Institute for Tropical Forestry)
- Yanira Cortes (USFS, International Institute for Tropical Forestry)
- Josh Fain (Yale University)
- Eva Holupchinski (USFS, International Institute for Tropical Forestry)
- Amanda Leinberger (Puerto Rico Departamento de Recursos Naturales y Ambientales)
- Vanessa Marrero (USFS, International Institute for Tropical Forestry)
- Carmen Plaud (USFS, International Institute for Tropical Forestry)
- Gary Potts (USFS, International Institute for Tropical Forestry)
- Maya Quinones (USFS, International Institute for Tropical Forestry)
- Lia Sanchez (USFS, International Institute for Tropical Forestry)
- Edwin Santiago (USFS, International Institute for Tropical Forestry)
- Sandra Soto-Bayo (USFS, International Institute for Tropical Forestry)
- Marinelis Talavera (USFS, International Institute for Tropical Forestry)

Appendix C: Detailed Stakeholder Feedback on Focal Area Issues

RESULTS: Responses from participants in each breakout group of the NCA4 Engagement Workshop - March 9, 2017

EXTREME EVENTS GROUP

Facilitator: Felix Aponte

Note taker: Nora Alvarez

Question	ROUND #1 PARTICIPANTS	ROUND #2 PARTICIPANTS
<p>1. Mention observed effects of extreme events due to climate changes</p>	<ul style="list-style-type: none"> • Increased fire events like forest fires • More frequent flooding, and associated impacts on infrastructure, supply chains, disease transmission, displacement of people • Displacement of people due to hurricanes • Crop damages from drought • Unsafe transportation between islands during extreme events (e.g. Culebra and Vieques) • Increases in pests • Heat waves and associated impacts, including increase in mortality rates, increase in energy use, decrease in tourism • Damages from landslide • Impacts of extreme events on the energy sector – wind effects can impact production and electric infrastructure 	<ul style="list-style-type: none"> • Increases in diseases in humans (zika, dengue, chikunguya) • Increases in pests, producing a chain of effects - more pests coming in, means more need to apply more pesticides, leading to more contamination and human health issues • Increased soil erosion due to increase rainfall • Wildlife behavioral changes caused by droughts (for example, elfin woods warbler experiences competition because of droughts, not enough fruits in the south, and now are moving to lower elevations in El Yunque) • Phenological changes are observed in crops- germination changes are responding to extreme events. We need to understand how to adapt during extreme events because they mainly depend on irrigation. • Hurricanes are increasing in strength. Small changes in hurricanes intensity can greatly increase impacts • Heat stress impacts the construction industry and outdoor exposure • Increases in wind speed causes damage to infrastructure • Accumulation of small extreme events can add to create big impacts • Warmer temperature at nights has increased humidity and increased mosquitoes • Ports and maritime commerce are increasingly vulnerable to extreme

		events, and, in island environments, external transportation is key.
2. Mention projected effects of extreme events in the next 20-30 years and by the end of the century due to climate changes	<ul style="list-style-type: none"> • Increase in expenditure in disaster response • There will be more frequent extreme events • Increase in the loss of properties • Increase in poverty • Decrease in success of the agricultural sector • Impacts on tourism and economy • Increase in impacts on infrastructure (dams, interruption of services, road floods) • US Army Corps of Engineers design should consider future trends - the current infrastructure is not design for the coming changes • Expecting more flood events • Impacts on road transportation in Saint Thomas, USVI • Relocation of people • Stronger hurricanes but less numbers – we should consider indirect impacts and cumulative effects • The impact of winter swells on coastal erosion is an emerging issue • Insurance rates will go up for everything 	<ul style="list-style-type: none"> • Perception of vulnerability due to extreme events or climate impacts such as disease transmission will have a big effect on tourism • Even small fluctuations (~5%) in climate conditions will have major impacts on tourism • Climate change will lead to increases in GMO crops that are temp/pest/drought/flooding-resistant. • Agriculture planning should take into consideration extreme events
3. Mention references or resources on this topic that we should be aware of	<ul style="list-style-type: none"> • USVI Gap Analysis (https://www.fs.usda.gov/tree-search-beta/pubs/37813) • Vista Dimension - Journal from the Colegio de Ingenieros (College of Engineers) on topics from water use to energy productions 	<ul style="list-style-type: none"> • CariCom – Caribbean Community (http://www.caricom.org/) • Javidan Rodriguez (now at NSF) - former professor at University of Puerto Rico Mayagüez- has written papers on disaster Management • Wayne Arendt study on elfin woods warbler (2013), accessible at:

	<ul style="list-style-type: none"> • Article: Islands in the Sun by Wayne Archibald (on author team), accessible at: http://ieeexplore.ieee.org/document/7050397/?reload=true • Puerto Rico Climate Change Council (PRCCC) - State of the Climate Report. 2010 report is accessible here: http://prccc.org/publications/prccc-documents/ • Urban heat papers by Pablo Mendez et al. (on author team). • Various papers by Elvira Cuevas at the University of Puerto Rico at Rio Piedras • Caribbean Community Climate Change Centre web site • National Weather Service Reports for PR and USVI • El Caribe Y El Cambio Climático: Los Costos de la Inacción 'The Caribbean and Climate Change: the Costs of Inaction' - by Ramón Bueno, accessible at: http://www.ase.tufts.edu/gdae/Pubs/rp/Caribbean-ES-Span.PDF 	<ul style="list-style-type: none"> • https://www.fs.fed.us/global/iitf/pubs/ja_iitf_2013_arendt001.pdf • Globe Teachers Guide //observer.globe.gov/ • Indigenous Phenology Network (https://www.usanpn.org/nn/indigeno-us-phenology-network) • USDA's Food and Agriculture Council - includes Puerto Rico, and announces when there is an extreme event.
<p>4. Mention adaptation success stories for addressing risk that can be highlighted</p>	<ul style="list-style-type: none"> • Caguas Bairoa 25 - Demolition and relocation of houses by floods in the neighborhood of Bairoa in the Puerto Rican municipality of Caguas. • European Union – has an insurance scheme to extreme events. Link to EU website: https://ec.europa.eu/clima/news/articles/news_2013041601_en • Cano Martin Pena Community Land Trust (https://www.bshf.org/world-habitat-awards/winners-and- 	<ul style="list-style-type: none"> • Crisis induces collaboration - examples among farmers in Cidra, Puerto Rico • Learning from small-scale collaborations, wherever they occur • One adaptive strategy used by cattle industry – selecting drought-tolerant breeds, e.g. the Senepol cattle in USVI. Infosheet accessible at: http://caribbeanclimatehub.org/wp-content/uploads/2016/06/Climate-Chnage-and-Livestock-factsheet.pdf • Youth environmental network in Caribbean (http://www.cyen.org/documents/homepage.html)

	<p>finalists/cano-martin-pena-community-land-trust/)</p> <ul style="list-style-type: none"> • Coastal Restoration projects for protection against erosion and impacts from extreme events. • Protocols for managing droughts 	<ul style="list-style-type: none"> • The Dominique youth and climate project - combining traditional and scientific knowledge
<p>5. What are the emerging issues and research gaps on this topic</p>	<ul style="list-style-type: none"> • More research is needed on winter swells impacts coasts • Research on the costs of inaction • Public education and outreach 	<ul style="list-style-type: none"> • Need to investigate germination cycle changes due to extreme events • Need to study accumulative impacts of smaller extreme events • Need research on drought, temperature stress, and wind resistant crop varieties • Bird migrations are being observed to the south – we need to study these patterns and the impacts on tourism • What is the gender role in disaster risk management and respond • Need to gather traditional knowledge - for food production and traditional medicine • We need to increase research on Education and Awareness, Cultural Practices • We need to develop multi-hazard approach - how to manage multiple events (e.g. Drought followed by floods)

FRESHWATER RESOURCES GROUP

Facilitator: Eric Harmsen

Note taker: Nora Alvarez

Question	ALL ANSWERS FROM PARTICIPANTS
<p>1. How have freshwater resources been affected by climate change?</p>	<ul style="list-style-type: none"> • Observed increases in total dissolved solids (TDS) in groundwater (about 200 mg/l in 1970, to 400 mg/l in 1970s and 1980s, to 800 mg/l current). In the Northeast, TDS is currently 1000- 2000 mg/l in comparison to 200 mg/l in the 1970s. A cause of this may be pumping wells for water supply. • Thickness of saturated layer in the North 200 - 250 ft, but what percent might be due to climate change? • Salinization of well water. • One participant noted that during the 2014- 2016 drought he received an inquiry from the media asking why reservoirs could not be constructed in high elevated mountain areas, which he had not experienced before. • Coastal springs are decreasing. • Less than 10 percent of rain recharges aquifers. We need water management programs that consider aquifer recharge. • Southern Caribbean has issues with fires. • Saline intrusion into coastal aquifers- in future drought events, saline intrusion may become a more prevalent issue (ex: Toa Baja is drier than it has been in the last 15 years). • Extraction of well water will increase with droughts. • Excess groundwater recharge from surface irrigation. • Groundwater recharge rate is very low. • Floods have affected freshwater resources. • Animal communities are migrating. • New water-borne diseases are emerging. • If minimum flow is lacking, the aquatic biota will suffer.
<p>2. How are freshwater resources projected to change by the end of the century?</p>	<ul style="list-style-type: none"> • Water availability will decrease due to less rainfall. • Extreme events will increase. • We need to keep changes in seasonality in mind. • Aquifer can be recharge will change due to changes in extreme precipitation events. • After dry periods, recharge may decrease due to water mostly running off of soil crusts. • With decreased groundwater recharge, the groundwater component in rivers will be lacking and base flow will decrease (although we do not have a handle on base flow and seasonality). • Seasons will change. • As rain patterns change, it will be more difficult to harvest rain. • Water infrastructure will continue to age. • Water treatment costs will increase.

	<ul style="list-style-type: none"> • USVI households rely on rainwater, and changing rainfall patterns will make this more difficult. Lack of understanding of existing resources (groundwater, etc) is another challenge. • River outflow changes coastal beaches. Change in river flow affect aquatic habitat. • As populations move to higher elevated areas due to sea level rise, they may affect freshwater resources and contaminate water.
3. Mention references or resources on this topic that we should be aware of	<ul style="list-style-type: none"> • Hydrologic conditions in the South Coast aquifer, Puerto Rico, 2010–15- Sigfredo Torres 2016 (author team member), accessible at: https://pubs.er.usgs.gov/publication/ofr20151215 • Water budget for El Yunque – produced by University of Georgia • Climate Change Implications for Tropical Islands: Interpolating and Interpreting Statistically Downscaled GCM Projections for Management and Planning - Azad Henareh (author team member), accessible at: http://journals.ametsoc.org/doi/abs/10.1175/JAMC-D-15-0182.1 • Fernando Quinones - table on operations for Autoridad de Acueductos y Alcantarillado (AAA, Puerto Rico’s Water and Sewer Authority) operations • Presentation on Sea Level Rise - Aurelio Mercado (author team member), available at http://pr-ccc.org/download/SLR-AurelioMercado.pdf • Water quality and freshwater resources produced by Gusavo Martinez of University of Puerto Rico, Mayaguez. • USGS Acuífero del sur y cambios de precipitación (USGS has produced information on the Southern aquifer and precipitation changes) • Pablo Méndez Lázaro (author team member) - cambio en precipitación en Río Piedras (‘changes in precipitation in Rio Piedras) • DNER / AAA website (Puerto Rico’s Water and Sewer Authority, http://www.acueductospr.com/) - info de embalses y acuíferos (information about reservoirs and aquifers) • http://PRAGwater.com - soil moisture and crop stress • http://UPRM.edu/courses from Hector Lopez - water usage, layouts for rainwater collection
4. Mention adaptation success stories for addressing risk that can be highlighted	<ul style="list-style-type: none"> • Success story – International Institute for Tropical Forestry rainwater harvesting and permeable pathways. • Success story- USVI requires 3 types of water tubing (roof, toilets, drinking/bathing) as a part of their construction regulations. • Success story - St. John’s hotel in USVI uses reclaimed water for garden. • Success story- Las Casas de la Selva sustainable forestry project has a wastewater garden. • Success story - Signs on storm water drains in some coastal areas indicate that the water drains directly to the ocean. • Success story - Ventana del mar - new vegetation was planted to avoid sand erosion. • Success story - Use of air conditioning condensation for toilet water. • Success story - 2014 - 2016 drought management was a success. • Successful use of cover crops to conserve water - strategic plan was also developed to manage water.

	<ul style="list-style-type: none"> • Opportunity - Due to recent PR drought, citizens are more aware of water resources. • Challenge - Water use must be improved because it is ineffective. • Challenges - Need more strategies to capture extreme events. • Challenge - Excessive use of freshwater by PR citizens. • Challenge - Poor will be more impacted by lack of water because they can't afford bottled water and other emergency options.
<p>5. What are the emerging issues and research gaps on this topic</p>	<p>EMERGING ISSUES/ NEEDS:</p> <ul style="list-style-type: none"> • Agriculture is growing, so the water demand will increase. Future conflict between agriculture and AAA (Autoridad de Acueductos y Alcantarillado, AAA is Puerto Rico's Water and Sewer Authority) for domestic water use. • Need to communicate to public - like Ariel Lugo's great Caribbean Business article on the drought. Need to increase scientific communication to public • Glyphosate (RoundUp) is used for weed control and it contaminates water because there are no laws to regulate. • AAA does not remove medicine or pesticides. • The lack of integration of agencies that work with water resources may dilute their efforts. • Need for public education. • Enforcement needs implementation. <p>RESEARCH GAPS</p> <ul style="list-style-type: none"> • A need for data on evapotranspiration. • Link between energy, water and food.

RISING SEA LEVELS & COASTAL EROSION GROUP

Facilitator: Aurelio Mercado

Note taker: Vanessa Marrero

Question	ALL ANSWERS FROM PARTICIPANTS
1. How have freshwater resources been affected by climate change?	<ul style="list-style-type: none"> • Effects on various types of coastal barriers (including mangrove forests, coral reefs) • Sea level is increasing, faster acceleration of sea level rise than expected has been observed • Loss of coastline due to erosion, especially beaches. • Changes in coastal habitats (e.g., Cabo Rojo in Puerto Rico) • Impacts on coastal tourism • Salt water intrusion into coastal aquifers • Impacts on physical structures close to the coast • Impacts on fishing communities
2. How are freshwater resources projected to change by the end of the century?	<ul style="list-style-type: none"> • Further loss of coastal habitat • Further impacts on marine species that are in shallow areas, with greater depth due to SLR • Increased salt water intrusion into coastal aquifers. • Impact on the quality of life (psychological well-being and recreation opportunities) by the loss of beaches • Increased coastal flooding (e.g. SJ airport flood) • Higher waves from cyclones, storms • Increased impacts on health, with flooded areas increasing vector-borne diseases and in some coastal areas overflow of wastewater (sewage)
3. Mention references or resources on this topic that we should be aware of	<ul style="list-style-type: none"> • IPCC assessment reports • Presentation on Sea Level Rise - Aurelio Mercado (author team member), available at http://pr-ccc.org/download/SLR-AurelioMercado.pdf • Puerto Rico Climate Change Council (PRCCC) - State of the Climate Report. 2010 report is accessible here: http://pr-ccc.org/publications/prccc-documents/
4. Mention adaptation success stories for addressing risk that can be highlighted	<ul style="list-style-type: none"> • In Puerto Rico - Juana Matos Community, has ecosystem-based adaptation projects. With the planting of mangroves and restoration of wetlands to avoid coastal flooding.
5. What are the emerging issues and research gaps on this topic	<ul style="list-style-type: none"> • Need to study the economic and social impact of: <ul style="list-style-type: none"> ○ community relocation (aging-vulnerable population); ○ the impact on ports and what this represents in the food security of PR • Need to understand economic impacts (e.g. on tourism) • Need for social research on land use planning.

	<ul style="list-style-type: none">• Need to better understand how flooding disrupts the daily routine of communities (eg Condado, Caño Martín Peña, etc.) and is linked to health

CHANGING OCEANS GROUP

Facilitator: Apurva Dave

Note taker: Amanda Leinberger

Observations: There were not many participants in this group, so this could either be an indicator of lack of presence of pertinent experts or a relative lack of priority (among those present and taking into consideration that among the 5 topics, there was only time to choose 2). This does not mean that these issues are not as important or should not be included in this U.S. Caribbean chapter. There is also an overlap between what is included in this group with what other groups are covering, e.g., extreme events and sea level rise. The areas in which this section is unique include coastal ecosystems (such as corals) and fisheries (displacement and changes in distribution of fish populations and changes in diversity of these ecosystems) and their connection to recreation and tourism.

For observed effects: We looked mainly at climatic stressors such as increased ocean temperatures, increased precipitation, and an increase in extreme events and how these are connected to effects in coastal ecosystems, fisheries, and tourism. Observed effects that we discussed include an increase in diseases, habitat loss, increased acidity, higher sedimentation output, increase in coral mortality, decrease in habitat, harmful algal blooms, and changes in primary production species.

Question	ALL ANSWERS FROM PARTICIPANTS
<p>1. Mention observed effects of climate change on oceans in the Caribbean.</p>	<ul style="list-style-type: none"> • We are observing: <ul style="list-style-type: none"> ○ Increased temperature ○ disease ○ habitat shifts ○ biodiversity decreases ○ increased CO2/acidity ○ increased coral mortality ○ increased extreme events ○ higher sediment deposition from coastal runoff
<p>5. What are the emerging issues and/or research gaps on this topic?</p>	<ul style="list-style-type: none"> • When we talk about changes in distribution of marine organisms, those changes of distribution occur in space and time and create complex interactions between the organisms and their environment. Therefore, it is very difficult to understand what the effect is, especially when there are many compounding climatic stressors on organisms. • We also highlighted the need for higher resolution hydrodynamic patterns. • There is a lack of understanding of sedimentation and pollution effects on corals specific to extreme events. For example, the amount of sedimentation discharged during one week of rainfall vs. one day (sensitivity to increased plumes distributed over shorter vs. longer time intervals). • Another gap is the need to understand which coral species are more resilient.

WARMING TEMPERATURES GROUP

Facilitator: Pablo Méndez-Lázaro

Note taker: Sandra Soto

Question	ALL ANSWERS FROM PARTICIPANTS
<p>1. Mention observed effects of warming temperatures in the Caribbean</p>	<ul style="list-style-type: none"> • Observed effects on habitats and different species include: <ul style="list-style-type: none"> ○ Impact on birds' nest & breeding times ○ Sex of sea turtles changing depending on the temperature of the sand. Higher temperatures results in more males ○ Decreased air quality (indoor & outdoor) • Human health: it has been found that human beings have a “thermal comfort” that is defined by the temperature to which you are exposed 75% of the time. This is why in PR we have less tolerance to higher temperatures, than our grandparents because we live in air conditioned systems. This also makes us more sensitive when temperatures increase and mortality rate is higher at lower temperatures.
<p>2. Mention projected effects of warming temperatures in the next 20-30 years and by the end of the century.</p>	<ul style="list-style-type: none"> • High uncertainty in temperature projections • Impacts on human health will include: <ul style="list-style-type: none"> ○ Exposure of general population and workforce (airports) ○ Cardiovascular & cerebrovascular effects ○ Increased mortality • Effects on agriculture will include: <ul style="list-style-type: none"> ○ Planting and harvest season change. This leads to changes on markets and has economic effects. Seasonal demand for products will have to change ○ Products are affected, such as milk production due to stress to livestock ○ More and new pests (shorter life cycle) ○ Higher demand of pesticides ○ Increased costs of production that won't lead to time of “barbechos” (fallow time) ○ Impact on agricultural productivity due to changes of plant/crop growth rate. Dehydrated soils. • Impact on tourism will include: <ul style="list-style-type: none"> ○ Decreased tourism due to the higher temperatures (tourists seek temperatures generally lower than 26°C? - and if you have higher temperatures than that people will stop visiting the country) • Impact on businesses will include: <ul style="list-style-type: none"> ○ Increased costs of production, due to higher costs of A.C. and electricity. This has a snowball effect and leads to higher costs to do business in general. ○ Economic problems, including a higher cost of living and higher production costs (e.g. plant nurseries have to control temperatures inside) • Increase in operational costs of hospitals or to keep food refrigerated (hygiene). • Impacts on society will include: <ul style="list-style-type: none"> ○ Poor communities will be more vulnerable, due to the fact that they don't have the resources to adapt ○ Older sector of the population will be more vulnerable

	<ul style="list-style-type: none"> • Impact on habitats will occur due to changes on plant growth or animal behavior, including bird breeding & nest times • In PR we will have more Saharan Dust arriving & more intense hurricanes & higher temperatures & stronger winds
3. Mention references or resources (reports, etc.) on this topic that we should be aware of.	<ul style="list-style-type: none"> • Joglar (2016) – paper on effect of climate change on ‘coqui’ (native Puerto Rican frog) • Raúl Pérez Rivera - effect on nesting patterns of “golondrinas” due to changes in precipitation because they need to nest on wet season • WMO - WHO Heat Warming Advisory 2015 • USDA - APHIS PPQ Annual Plant Board • Laboratorio Agrológico Estatal (State Agricultural Laboratory of Puerto Rico, has info on pests, soils) • Journal UPR - Mayagüez - Ciencias Agrarias (Agricultural Sciences journal)
4. Mention adaptation success stories for addressing risk that can be highlighted.	<ul style="list-style-type: none"> • Heat early warning systems • Planting of trees in areas with livestock • Shade Coffee and Forest Conservation in the Face of Climate Change (https://www.youtube.com/watch?v=OmARSJdOuXs) • Federal incentive programs through USDA, for sustainable agriculture • Josco Bravo (El Josco Bravo Agro-ecological Project) https://www.facebook.com/Proyecto-Agroecol%C3%B3gico-El-Josco-Bravo-107075809404135/?ref=page_internal • USVI is looking for plants with better resilience to increased temperatures
5. What are the emerging issues and/or research gaps on this topic?	<ul style="list-style-type: none"> • Education on climate and temperature impacts (K-12, curricula for engineers and architects, general population awareness) • Need to understand the costs associated with inaction • Impacts of warming temperatures on emerging diseases and vectors. • Relationship between climate impacts and Social inequality • Green infrastructure and heat reduction in buildings