PUERTO RICO

MITIGATION ACTION PLAN

Community Development Block Grant - Mitigation *(CDBG-MIT)*

DRAFT FOR PUBLIC COMMENT

60-DAY PUBLIC COMMENT PERIOD

START: September 21, 2020

END: November 20, 2020

This is a draft document subject to change.

December 2020

*Note: This cover page was updated on November 5, 2020 to extend the end date for the public comment period to November 20, 2020.

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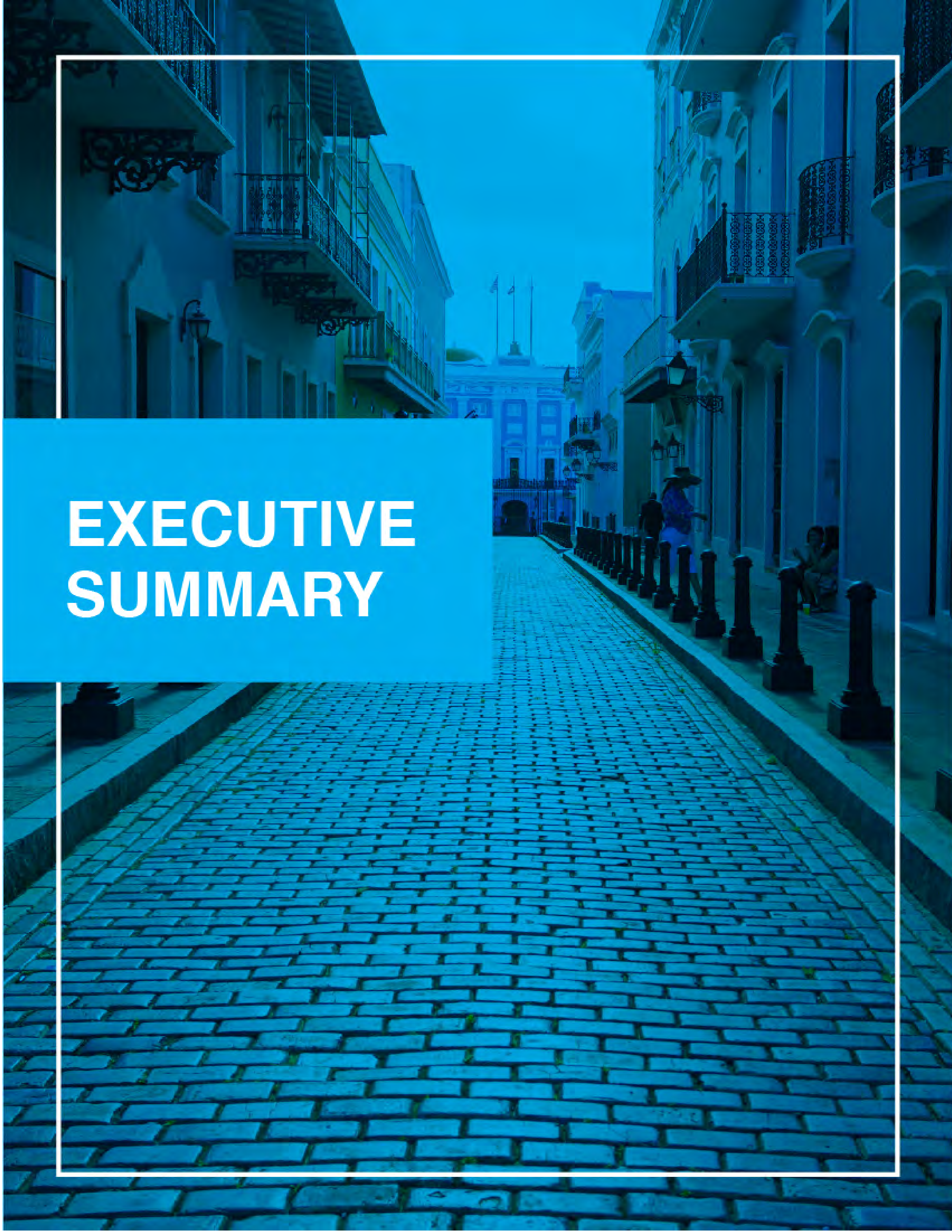

EXECUTIVE SUMMARY

Nestled in the Caribbean more than 1,000 miles from the nearest shore of the contiguous United States (**US**), Puerto Rico, a US territory since the year 1898, is home to roughly 3 million Americans. The natural gifts of this archipelago are plentiful—the National Park System's only tropical rain forest is here, as are several bays filled with bioluminescent sea life, but the nature in Puerto Rico can also be fierce. Its people have had to endure and recover from a long history of hurricanes, earthquakes, landslides and other natural disasters, the most devastating of these being Hurricanes Irma and María, which hit the Island[1] just weeks apart, in 2017. These events were declared the worst natural disaster in US history and left millions without power, without the ability to communicate, and many without food, water, or homes.

Because of this fierce nature, when decisions are made about Puerto Rico they must always ask: "will this decision make Puerto Rico more resilient or less so?" Puerto Ricans constantly face climate-sensitive and catastrophic weather events, climate-induced erosion on aging facets of the built environment, landmass-threatening sea level rise and coastal flooding, and earthquakes and tremors from shifting tectonic plates. While the people have shown their resiliency, their systems—everything from policy to the built environment and from energy and communications to the roads—have often proven not to be resilient.

Disaster resilience was defined in a study by Susan Cutter, Kevin Ash, and Christopher Emrich as that which "enhances the ability of a community to prepare and plan for, absorb, recover from, and more successfully adapt to actual or potential adverse events in a timely and efficient manner including the restoration and improvement of basic functions and structures." The researchers go on to say, "In its original ecological context, the notion of bouncing back to the pre-impact state defined resilience, but in the disaster context, this has been expanded to include measures of betterment – bouncing forward, not merely just bouncing back."[2] After all, the point of mitigation is to avoid the loss of life, the destruction of property and land, and the exorbitant cost of rebuilding what was torn apart.

The researchers also postulate that resilience is a regional feature. While all of Puerto Rico may suffer from a disaster, the various communities suffer in different ways and have unique resources to help them recover. Any disaster mitigation plan needs to respect the importance of that regionality.

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[1] Puerto Rico is an archipelago that consists of one (1) main island, two (2) small inhabited islands, and over 130 smaller islands and cays. Throughout this document, the term Island is used interchangeably with Puerto Rico, and is meant to encompass the entire archipelago of Puerto Rico.

[2] Cutter, Susan L., et al. "The Geographies of Community Disaster Resilience." Science Direct, Global Environmental Change, Mar. 2014, www.sciencedirect.com/science/article/abs/pii/S0959378014001459.

Nature demonstrates that indigenous flora and fauna tend to weather harsh local conditions more heartily than transplants. That principle also applies to the human systems and built environments for Puerto Rico. Many of the decisions regarding policy, infrastructure, system design, and more have used models and resources from afar; resulting in a Puerto Rico that is dependent on sustained external support to function: foreign investment, imported fuel, and imported food. All of these external lifelines rely on complex supply chains with many potential points of failure. Consequently, they cannot be called resilient. These systems proved fragile during Hurricane María. And though not all hurricanes or weather events approach the severity of María, studies show that hurricanes of that magnitude, as well as flooding, sea level rise, and other natural events that threaten Puerto Rico's people, are expected to increase with climate change[3].

The future resilience of Puerto Rico may rely on rooting the Island's systems in its own communities: supporting the development of local resources that don't rely on complex supply chains which have proven to be fragile during disasters. Ensuring that strengthening local solutions, local enterprises, and residents' authority to influence decision-making that empowers them to rebound quickly after a hurricane is emphasized. This report investigates the fragilities within Puerto Rico's interconnected lifelines and sectors: food, safety, shelter, water, energy, communication, healthcare, transportation. It focuses on the factors that contribute to that systematic fragility within Puerto Rico's interconnected lifelines, as well as factors that mitigate that fragility to enable clearer decision making about what shifts must happen in the built environment, in policies, and in systems, to create resiliency. Federal funds and a regional approach[4] to planning that puts forward sustainable solutions rather than immediate fixes would result in a Puerto Rico that could not only bounce back but rather bounce forward, using the last event's failures as a guide for creating strength against the next event's assault. For the Island to truly be resilient, the mindset must change toward long-term sustainability.

In this report, the Puerto Rico Department of Housing (**PRDOH**) is serving the interest of the Puerto Rican people, investigating eighteen (18) potential weather-induced and human-caused hazards that encroach on the safety and well-being of Puerto Rico. This data-driven quantitative analysis forms the basis of our understanding for mitigation needs, and considers the qualitative input gathered from citizens as well as federal, state and local service provider entities and non-governmental organizations (**NGO**s), with an operational presence in Puerto Rico. More than forty (40) public reports and over ninety (90) publicly available data sets were consulted in this analysis.[5] PRDOH further substantiated this understanding of need by conducting extensive stakeholder

[3] "Global Warming and Hurricanes." *GFDL*, 12 June 2020, www.gfdl.noaa.gov/global-warming-and-hurricanes/
[4] The term "regional" considers that Puerto Rico's seventy-eight (78) municipal jurisdictions overlay the Island's four (4) mountain ranges, 200+ rivers, 102 watersheds and four (4) geological zones as well as multiple transportation systems, infrastructure service areas, agricultural communities, and economic centers.
[5] See full bibliography in appendix to the Action Plan.

engagement between the months of May and August 2020[6]. As a result, the Risk-Based Mitigation Needs Assessment and the Mitigation Programs in this report factor in characteristics and impacts of current and future hazards that threaten the infrastructure and services indispensable to the continuous operation of business and government functions critical in a disaster event, and essential to human health, safety, and economic security.

A New Understanding of Local Risk

The Risk Assessment in this report broadens Puerto Rico's understanding of risk – weather-induced or human-caused – and makes this information available to the public at the Island-wide and municipal level, and through the release of an interactive Risk Assessment Dashboard, down to a half-mile hexagonal grid level.

PRDOH utilizes the Department of Homeland Security (**DHS**) extended risk definition[7] to determine measurable risk in as universal a language as possible, making the results accessible for planning across federal funding sources beyond those addressed in this Action Plan. Here, risk is the potential for an adverse outcome assessed as a function of threats, vulnerabilities, and consequences associated with an incident, event, or occurrence. The equation shown below illustrates this concept showing that Vulnerability times Hazard times Consequence equals Risk.

$$RISK_{HAZ_n} = (VUL)(HAZ_n)(CON_{HAZ_n})$$

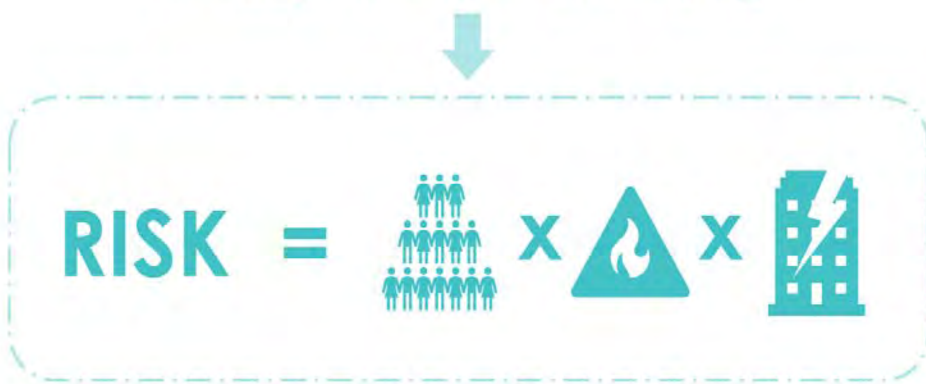

Figure 1. Risk Assessment Equation

In order to complete the Risk Assessment, PRDOH had to first understand what hazard types exist and where those hazard types are most likely to occur within Puerto Rico's geography in the future. PRDOH then had to understand how those geographically based occurrences interact with the natural and human-built environment, and the population of Puerto Rico. The overlay of data from these components of the equation are what define our understanding of the risk. To determine vulnerability, three (3)

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[6] Stakeholder engagement was conducted via Zoom and Microsoft Teams web-based meeting platforms to allow for social distancing during the Coronavirus 2019 (COVID-19) pandemic.

[7] DHS Risk Lexicon, Department of Homeland Security. September 2008. Accessed at: https://www.dhs.gov/xlibrary/assets/dhs_risk_lexicon.pdf

indicators were considered: critical infrastructure density, areas with high social vulnerability, and population density.

PRDOH has evaluated a total of eighteen (18) possible threats based on the common occurrence of these hazardous events in the US and the likelihood of occurrence in the Caribbean. The results of this analysis reveal Puerto Rico's most threatening hazards at the state-wide (or Island-wide level), which are ranked in the table below.

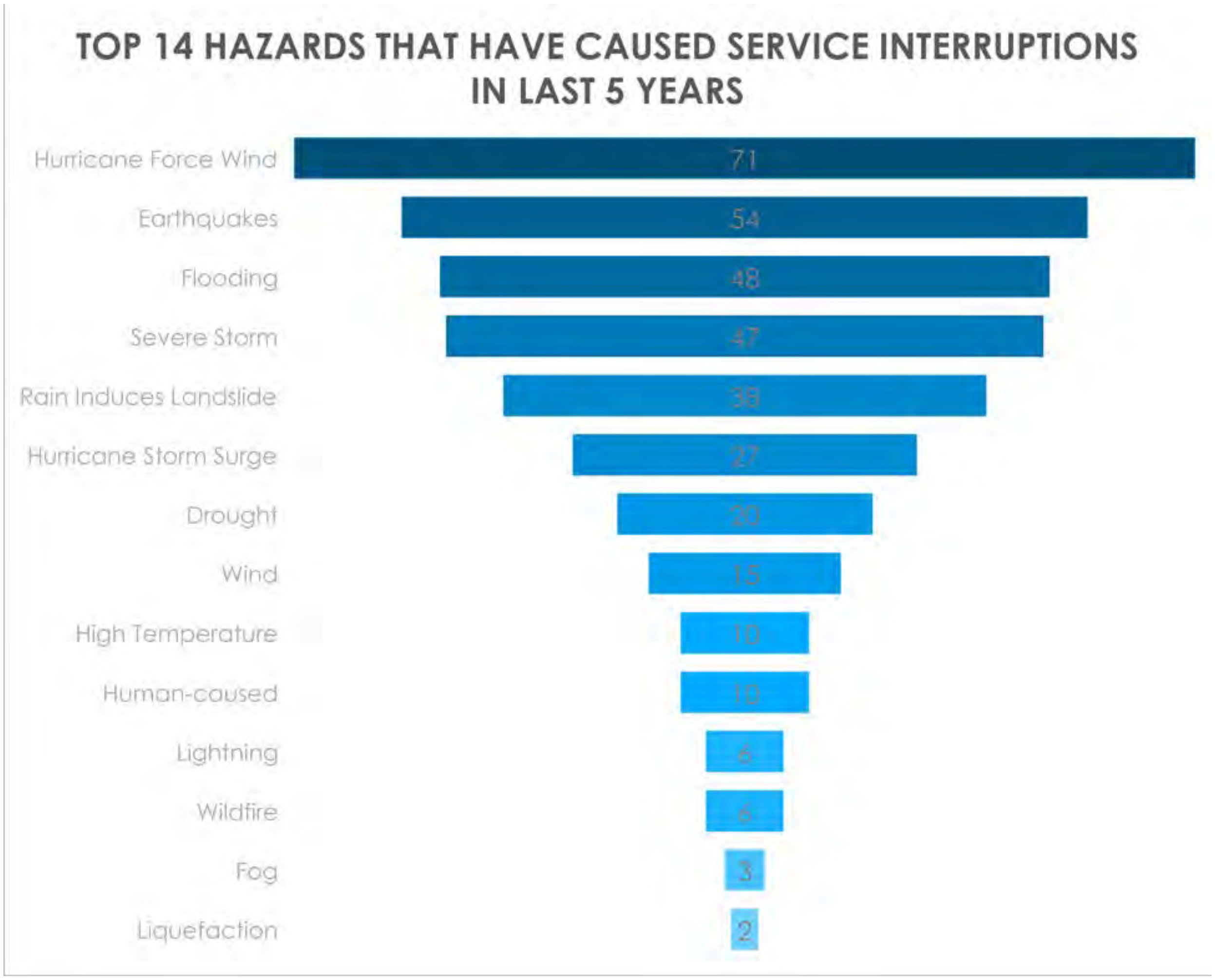
Risk Assessment Results at Island-Wide Level

1	Hurricane Force Winds
2	Flood (100-year)
3	Earthquake
4	Landslide
5	Liquefaction
6	Drought
7	Severe Storm
8	Sea Level Rise (10 ft)
9	Wildfire
10	Human Hazard
11	Fog
12	Lightning
13	Category 5 Storm Surge
14	Tornado
15	Tsunami
16	Wind
17	Hail
18	High Temp

Public Perception of Top Risks

These results were assessed for ground truth in a Service Provider Survey released to over 240 services provider entities in Puerto Rico which included Municipalities, state agencies, and non-governmental organizations. Seventy-six (76) entities responded and indicated all of the eighteen (18) assessed hazards that have caused interruption to their service(s) in the past five (5) years. The results showed that the top hazard causing most interruption to service in last five (5) years is hurricane force winds, which is consistent with the top risk identified in the PRDOH risk assessment. Both the risk assessment and the survey identify the same hazards as being the top three (3) risks.

Hazards that have Affected Service Providers in Past 5 Years



Risk Assessment Results at the Municipio Level

This ranking of risk differs slightly when considering the top threats of the geographic area within each municipal government boundary. Hazards that appear in the top eight (8) risks at the Island-wide level, emerge in seven (7) different combinations at the municipal level. This evaluation of municipal level data can be shown color-coded by the top two (2) threats per municipality in the map show on the following page.

Risk Assessment Results for Municipio Top 2 Threats

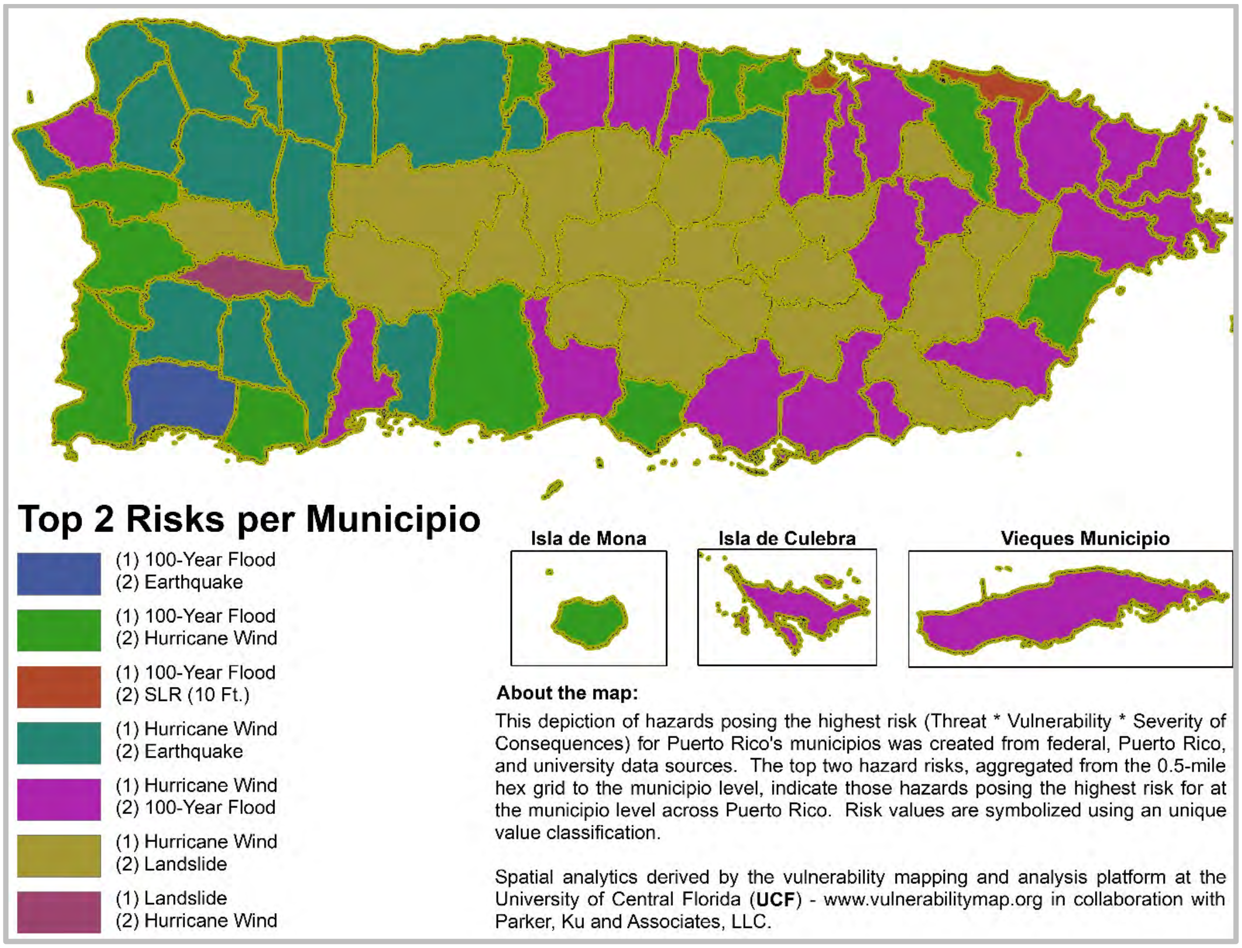


Figure 2. Map of Top Two Risks by Municipality

This narrowed in perspective of risk rankings at the municipal level offers a more localized understanding of what risks exist within each municipal area allowing residents, elected officials, and decision-makers to share a common understanding of what risk they face and should therefore mobilize resources to mitigate.

And finally, to permit project-level planning at the most granular level possible, risk rankings are published in this report and made available to the public through interactive web-based tools that demonstrate a risk ranking down the half-mile hex grid level.

When represented geospatially the Island-wide risk depicted in the map below shows a more granular look at the top risk by half-mile hex grid.

Risk Assessment Results by Hex Grid at Island-Wide Level

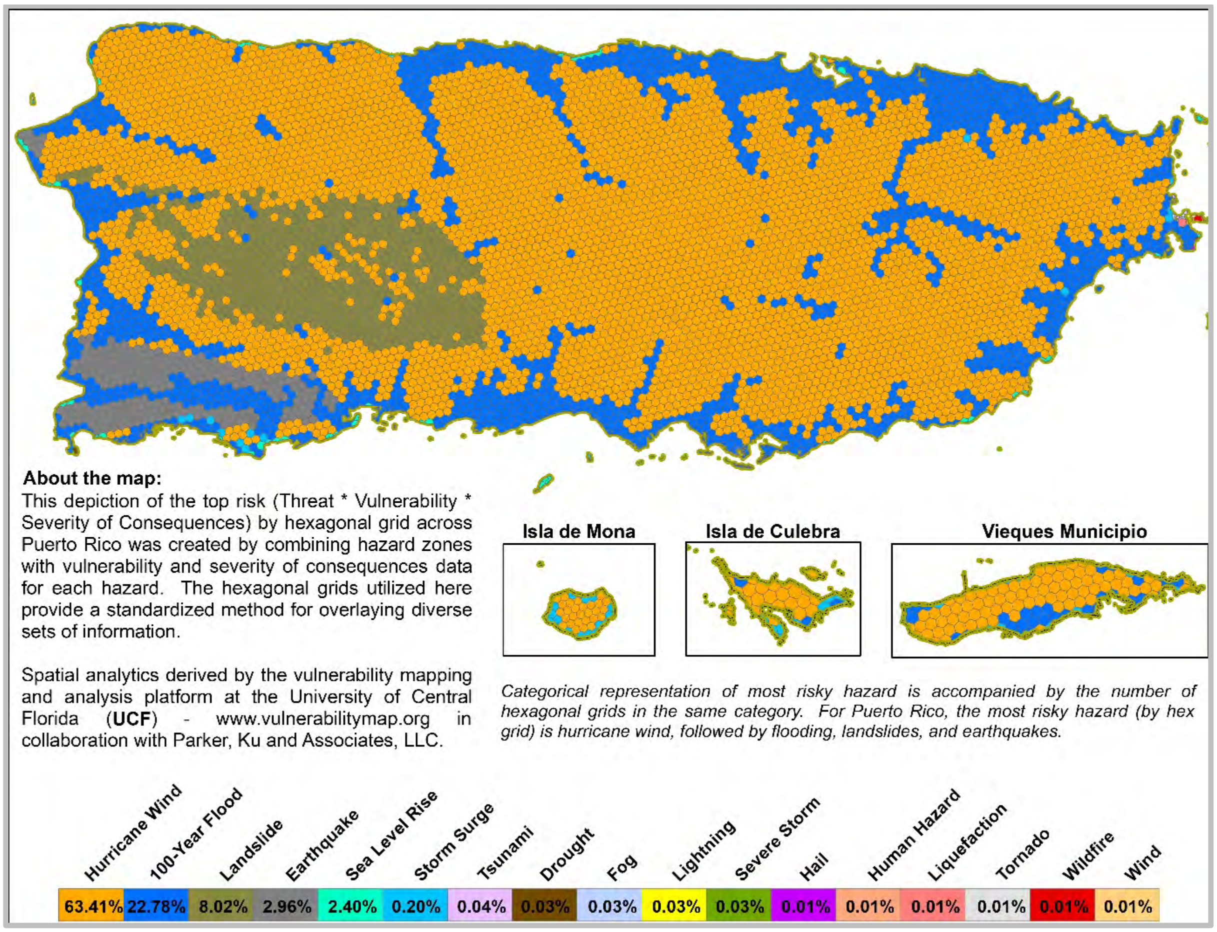


Figure 3. Map Depicting Top Risk per Hexagonal Grid

Incorporating Lifelines into the Risk-Based Needs Assessment

In its 2017 Hurricane Season After-Action Report, the Federal Emergency Management Agency (**FEMA**) utilized a relatively new construct for disaster planning and response that centers on the stability of critical infrastructure understood in groupings of community lifelines.[8]

Lifelines are the integrated network of assets, services, and capabilities used day-to-day to support the recurring needs of the community. FEMA's community lifelines construct establishes a national standard for disaster response, recovery, and preparedness, including mitigation. The lifelines construct recognizes that communities depend on a network of interdependent systems that involve public and private entities including

[8] 2017 Hurricane Season FEMA After-Action Report. FEMA. July 12, 2018. Accessed at: https://www.fema.gov/sites/default/files/2020-08/fema_hurricane-season-after-action-report_2017.pdf

everything from utilities to hospitals to supermarkets. At any point along the lifeline, a failure can result in cascading failures in other directions.

These concepts are considered in the Risk-Based Needs Assessment in this report. Stabilizing community lifelines in catastrophic incidents is vital and requires improved coordination and response structures, reinforced through long-term permanent solutions that mitigate the impact of disaster events.

As Puerto Ricans look toward their collective future and make decisions about how to mitigate natural and human-caused hazards and instabilities, several organizing principles emerge. These organizing principles form a common thread throughout the Risk-Based Mitigation Needs Assessment and inform the programmatic response to the mitigation needs identified therein. These organizing principles are:

- **Reduce system fragility** by lessening the impact of hazard events on the built environment, social structures, and ecological systems.
- **Improve the adaptive capacity of Puerto Rico** by removing impediments to long-term systemic change and promoting collaborative governance at multiple scales.
- **Create self-sustaining, regenerative systems** that have the ability to persist or thrive through physical, economic and social challenges after a hazard event.

Programs Designed to Meet Stakeholder Needs

Between the months of May and August 2020, PRDOH conducted an extensive stakeholder engagement effort to consult with municipalities, academia, non-governmental entities, and other Puerto Rican agencies to gain a community-driven understanding of Puerto Rico's mitigation needs. This was completed while contending with COVID-19 social distancing requirements and local restrictions.[9]

Because these funds are intended to mitigate against a multitude of risks rather than a single disaster event with a defined cost for recovery, stakeholder input on Puerto Rico's long-term mitigation needs became paramount to the planning process. As of August 3, 2020, PRDOH has conducted outreach to 150+ stakeholder entities which includes: federal agencies, state agencies, municipalities and NGOs.

[9] On March 12, 2020, Governor Wanda Vazquez issued executive order OE-2020-020 declaring a state of emergency in Puerto Rico.

Figure 4. Illustration of stakeholders engaged during CDBG-MIT Action Plan planning process

Stakeholders were asked to provide a Proposed Project Log to inform the program planning process to ground-truth the research completed in the Risk-Based Needs Assessment. This aspect of the stakeholder engagement produced over 1,600 requested projects totaling nearly $11 Billion in estimated cost[10]. Project requests revealed the most need to be in four (4) lifelines with respect to estimated project cost are: Water/Wastewater (42%), Flood Control[11] (21%), and Medical (14%), and Transportation (13.1%).

When evaluated for alignment with programmatic activities, these project requests showed an overwhelming need for infrastructure mitigation, and a surprisingly substantial need for planning – which was consistent with themes discussed in roundtable sessions. Programmatic activities in order from highest to lowest are: Infrastructure (88%), Planning (6%), Housing (6%), and Economic Development (0.3%).

Conclusion

The geographic realities of living on a Caribbean Island, only 3,400 square miles in size that shares no state borders and is separated from its mainland country by more than 1,000 miles of open sea, require a mitigation-focused approach to federally-backed investment in housing, infrastructure, and economic recovery, which must result in a demonstrable reduction in risk for the Island.

As the recovery needs in Puerto Rico increase with each disaster, the need for mitigation is ever present. The Government of Puerto Rico has been allocated $8.285 billion in

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[10] The full results of stakeholder engagement activity will be published in a separate report and attached to the Action Plan as an appendix.

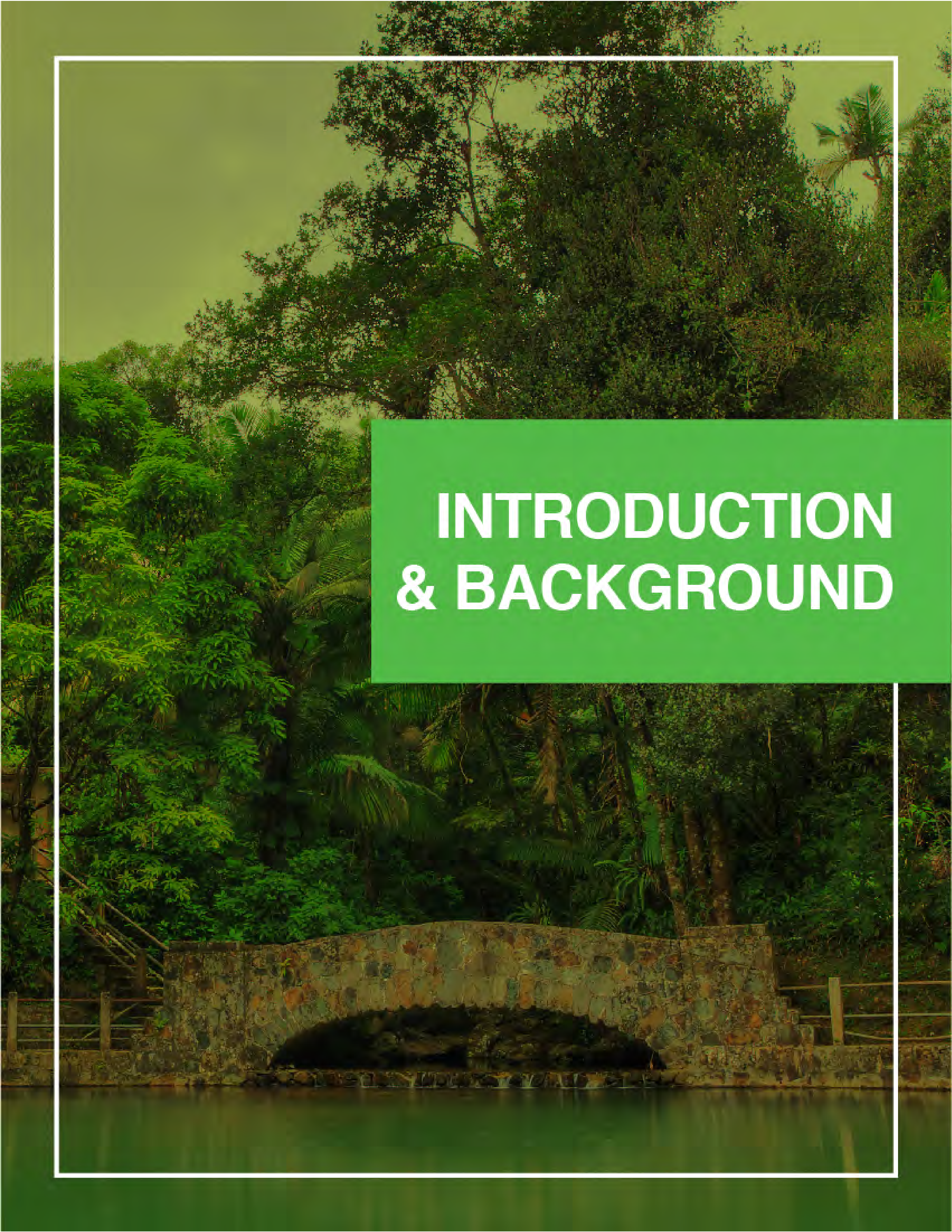
[11] Flood control is a subsector of the Community Safety sector of the Safety and Security lifeline but serves to mitigate risk to physical assets within all other lifelines.

Community Development Block Grant – Mitigation (**CDBG-MIT**) funding for long-term planning and risk mitigation activities.

CDBG-MIT Programs in this Action Plan are structured to align with best practice mitigation guidance and current capital investments planned for the Island. PRDOH has identified four (4) unifying strategies built into the Mitigation programs to align with the coordination of mitigation projects and leverage requirements found at Federal Register Vol. 84, No. 169 (August 30, 2019), 84 FR 45847. These unifying strategies are woven into program design and incentivized through evaluation criteria and supported by the development of capacity-building tools, including the Risk Assessment evaluation tool released during stakeholder engagement. These strategies include:

- **Capacity Building**: Make central the importance of continued planning, transparency of information and data sharing critical to emergency response and resilience and increase the planning and implementation capacity for entities and citizens. A key component of increased capacity is also tied to the adoption of policies and procedures that reflect municipal and regional priorities with long-lasting effects on community risk reduction.
- **Community and Regional Investment**: Reduce the conditions of risk through community and regional level projects that identify transformative mitigation opportunities that serve the needs of vulnerable communities and reduce the displacement of individuals.
- **Lifeline Stability and Strengthening**: Strengthen the critical lifelines through prioritizing infrastructure improvements that avoid or reduce disruption of critical services while promoting sustainability.
- **Alignment of Capital Investments**: Alignment of CDBG–MIT programs and projects with other planned federal, state, regional, or local capital improvements.

INTRODUCTION & BACKGROUND



INTRODUCTION & BACKGROUND

Introduction

Understanding that resilience is a regional feature, PRDOH places emphasis on the public's understanding of Puerto Rico's characteristics in terms of people, history, and the natural and built environment.

The archipelago of Puerto Rico is home to a melting pot of people with roots from the Taíno Indians, Spanish, French, British, African, Asian cultures, and a multitude of other backgrounds. It has a rich and storied cultural history that spans centuries.

Puerto Rico is part of the Caribbean Islands, comprising more than 700 islands, islets, reefs, and cays surrounded by the Caribbean Sea. To the north, the region is bordered by the Gulf of Mexico and the Straits of Florida, and to the east and northeast is the Northern Atlantic Ocean. To the south lies the coastline of the continent of South America and the northern coast of Venezuela. It exists at the confluence of the Caribbean and North American Tectonic Plates, an active boundary that has shaped the region and created the Caribbean Islands.

The main Island of Puerto Rico measures 3,400 square miles, slightly larger than the US state of Rhode Island. It is mostly mountainous, with large coastal areas in the north and south regions of the Island. The main mountain range is called La Cordillera Central and is home to the highest elevation point of Puerto Rico, Cerro de Punta (4,390 feet). The capital, San Juan, is located on the main Island's north coast.

The combination of the warm, wet climate, coastal floodplains, beaches and interior mountains produced a region rich with opportunity for fishing, grazing livestock, agriculture, ocean economies, as well as coastal development. While this location in the Caribbean Sea produced a varied history of exploration and settlement, it also makes Puerto Rico uniquely vulnerable to a multitude of natural disruptions and disasters, such as hurricanes, floods, earthquakes, supply line disruptions, and economic isolation. And it necessitates that mitigation strategies to deal with these disasters may vary significantly from one region to the next.

The Importance of Systemic Stability

In the context of disasters, a resilient system supports continued and reliable access to basic services important to the health and safety of the population. Citizens need safe and sanitary water utilities, reliable power, access to supplies and safety routes, the means to communicate, and adequate flood and drainage systems to remove vector-borne threats.

Stabilization occurs when basic lifeline services are available prior to, during, and post-disaster. Mitigation not only minimizes disruption but should also reduce the need for restoration of services in the event of temporary failure.

In September 2017, Hurricanes Irma and María cut across Puerto Rico's three (3) inhabited islands, crippling the power grid and communication systems, flooding coastal and alluvial plains, and causing significant landslide and wind damage. All seventy-eight (78) municipalities were subsequently declared disaster impact areas under Puerto Rico Hurricane Irma DR-4336 and Puerto Rico Hurricane María DR-4339. **Three** (**3**) **years** later, on January 6, 2020, a 5.8 magnitude earthquake shook the Island, and was followed by a 6.4 magnitude earthquake the next day. The regions most impacted by these earthquakes were declared disaster impact areas under presidential declaration[12] DR-4473, and the Island continues to experience aftershock tremors. The people of Puerto Rico are now facing the worldwide pandemic of the Coronavirus Disease 2019 (COVID-19), a disaster under presidential [13] DR-4493-PR, and are experiencing severe impacts as import and export economies are affected and social assistance is limited, coupled with vast challenges in remote educational systems, and a limited healthcare system. In the **three** (**3**) **years** since September 2017, Puerto Rico has experienced three (3) presidentially declared disasters, and has responded to a multitude of other threats, including tropical storms, hurricanes, earthquake aftershocks, droughts, population loss, and ongoing economic insecurity.

These social, environmental, and technological conditions of Puerto Rico contribute to snowballing challenges across the Island and loss of adaptive capacity over time. As hazard events continue to impact the Island, economic insecurity rises, and lifeline assets – resources such as transportation routes, communication systems and healthcare facilities that support human habitation – fall into disrepair. The people of Puerto Rico are increasingly exposed to life changing events and difficulties.

Mitigation Allocation

On February 9, 2018, the President signed into law the Bipartisan Budget Act (Public Law 115-123). This made available $28 billion in Community Development Block Grant – Disaster Recovery (**CDBG–DR**) funds and directed the US Department of Housing and Urban Development (**HUD**) to allocate no less than $12 billion for mitigation activities proportional to the amounts that grantees received for qualifying disasters in 2015, 2016, and 2017. That amount was increased to $15.9 billion after HUD completed an assessment of unmet needs and awarded funding to a total of eighteen (18) grantees through a newly created Community Development Block Grant - Mitigation (**CDBG-MIT**) Program.[14]

The rules for administering these funds are founded in the regulatory framework of HUD's Community Development Block Grant (**CDBG**) program and further consider the alternative requirements, waivers, and special grant conditions released in the following Federal Register Notices:

- Federal Register Vol. 84, No. 169 (August 30, 2019), 84 FR 45838

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[12] United States. FEMA. "President Donald J. Trump Approves Major Disaster Declaration". https://www.fema.gov/es/news-release/20200220/el-presidente-donald-j-trump-declara-un-desastre-mayor-para-puerto-rico-0 . Accessed 30 August 2020.

[13] United States. FEMA. "President Donald J. Trump Approves Major Disaster Declaration". https://www.fema.gov/news-release/20200514/president-donald-j-trump-approves-major-disaster-declaration-commonwealth . Accessed 30 August 2020.

[14] United States. HUD. "HUD Awards $28 Billion in CDBG-DR Funds.", Housing and Urban Development website, April 11, 2018, https://www.hudexchange.info/news/hud-awards-28-billion-in-cdbg-dr-funds/. Accessed on 13 June 2020.

- Federal Register Vol. 85, No. 17 (January 27, 2020), 85 FR 4676

These grant funds have been allocated for a broad range of activities intended to support mitigation projects that reduce the potential for loss and destruction from future events. Mitigation funds have been awarded due to the extensive damage that Puerto Rico sustained from Hurricanes Irma and María, but they can be used for complex mitigation needs beyond hurricane-posed threats. Puerto Rico and The US Virgin Islands currently await another $1.9 billion in HUD grant funds to be allocated specifically for enhancing or improving electrical power systems.

For Puerto Rico, mitigation is key to the rebirth of the Island in the wake of a series of disaster-inducing events. The opportunity to mitigate future loss by restoring and improving the social, ecological, and technological facets of the Puerto Rican system can mean the difference between stability and disruption for the future.

What is Hazard Mitigation?

For the CDBG-MIT program, HUD defines mitigation activities as: "...activities that increase resilience to disasters and reduce or eliminate the long-term risk of loss of life, injury, damage to and loss of property, and suffering and hardship, by lessening the impact of future disasters."[15]

HUD has designed the CDBG-MIT program to complement the existing mitigation programs currently administered by FEMA. For these existing programs, FEMA defines mitigation as "… [E]fforts to reduce loss of life and property by lessening the impact of disasters."[16]

Loss Prevention through Mitigation

PRDOH realizes that within the immense challenges Puerto Rico faces to recover from disastrous events, there also lie immense opportunities to institute true mitigation measures that protect the Island from future risks. The allocation of CBDG-MIT funds for Puerto Rico is a significant additional resource to ensure those opportunities become realities.

[15] United State, HUD. "Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees." 84 Fed. Reg. 45840. (August 30, 2019)
[16] United States. FEMA. "What is Mitigation", FEMA website, 2020, https://www.fema.gov/what-mitigation, Accessed 13 June 2020.

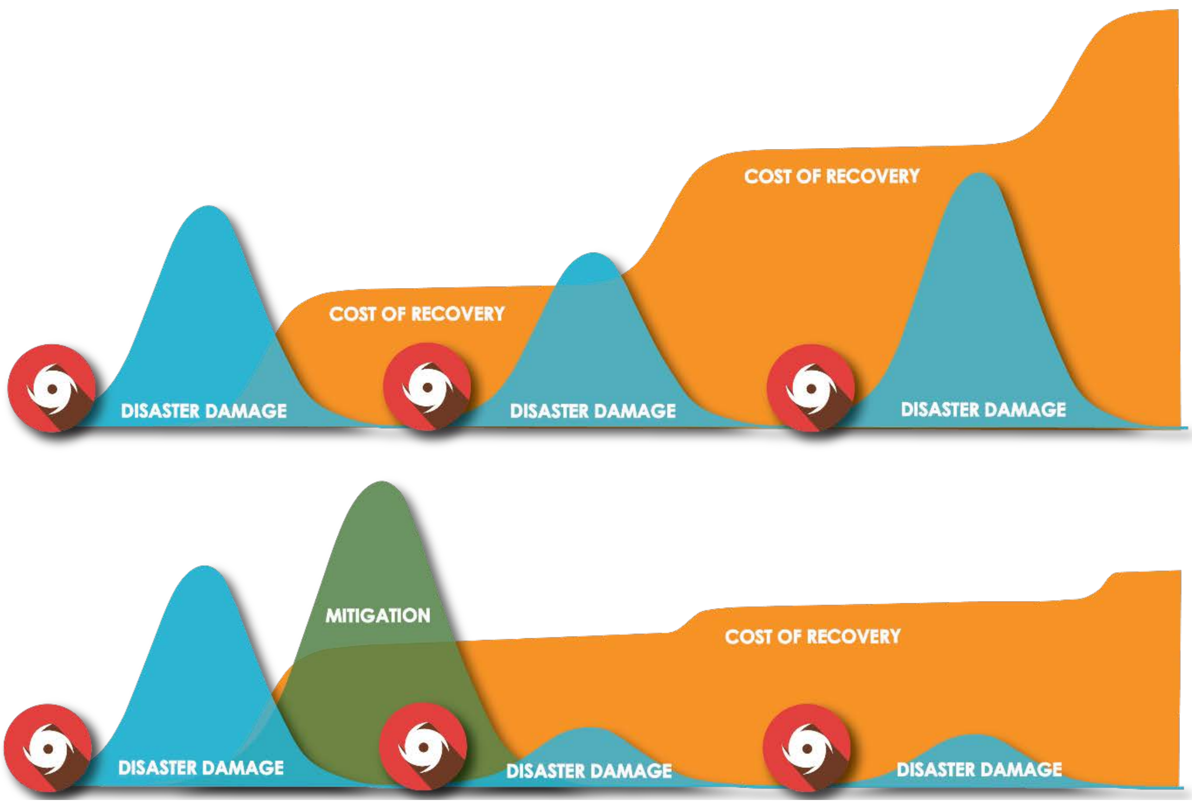

Figure 5. Illustration of the positive impact mitigation activity can have in reducing the cost of recovery for the future.

As shown in the image above, Puerto Rico is at a pivotal point in history in which the Island can significantly improve the outlook for its own future through intentional mitigation spending that lessens the impact of future hazardous events. The strategic investment in mitigation could greatly reduce the risk of compounded recovery costs in the future if Puerto Rico prepares ahead for the certainty of climate-sensitive weather-related threats that continue to grow in intensity and occur with greater frequency.

The CDBG-MIT grant, in combination with FEMA Hazard Mitigation Assistance (**HMA**) programs, mitigation projects funded by the US Army Corps of Engineers (**USACE**), and projects of other federal entities, offers Puerto Rico true potential for mitigating loss of life and damage to critical infrastructure for the future. Research performed by the National Institute of Building Sciences (**NBIS**) has long been cited in FEMA HMA programs to quantify the cost savings for both the public and private sectors. In 2005, the NBIS Multi-Hazard Mitigation Council (MMC) in partnership with FEMA, released the initial *Natural Hazard Mitigation Saves* study.[17], which looked at the value of using federal grants to assist with mitigation. Researchers determined that hazard mitigation saves, on average, four dollars ($4) for every one dollar ($1) spent on federal mitigation grants. In the more recent

[17] National Institute of Building Sciences. *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities* (2005). http://www.nibs.org/mmc_projects#nhms

2019 *Natural Hazard Mitigation Saves* study[18], the NBIS updates this number to a ratio of six dollars ($6) to one dollar ($1). In the latest iteration of the study, the NBIS expands its evaluation to examine five (5) sets of mitigation strategies across select disaster-causing events to consider the cost of building retrofits, lifeline retrofits, and code compliance both at and above code requirements.

Recovery and Mitigation

Response, recovery, and mitigation each play a crucial role in reducing the inherent instability brought about by disasters and in addressing the ongoing crises that can ensue. While response funds provide immediate relief from disaster conditions, and recovery funds repair the damage caused by a specific event, mitigation funds are intended to prevent or reduce damages from future events— supporting resiliency. The Territory of Puerto Rico has received disaster response and recovery assistance in the form of multiple federal grants and allocations through FEMA, USACE, USDA, EDA, and CDBG-DR, and others. As stated in 84 FR 45838, Mitigation funds allocated through the CDBG–MIT program are to be used for distinctly different purposes than CDBG–DR funds.

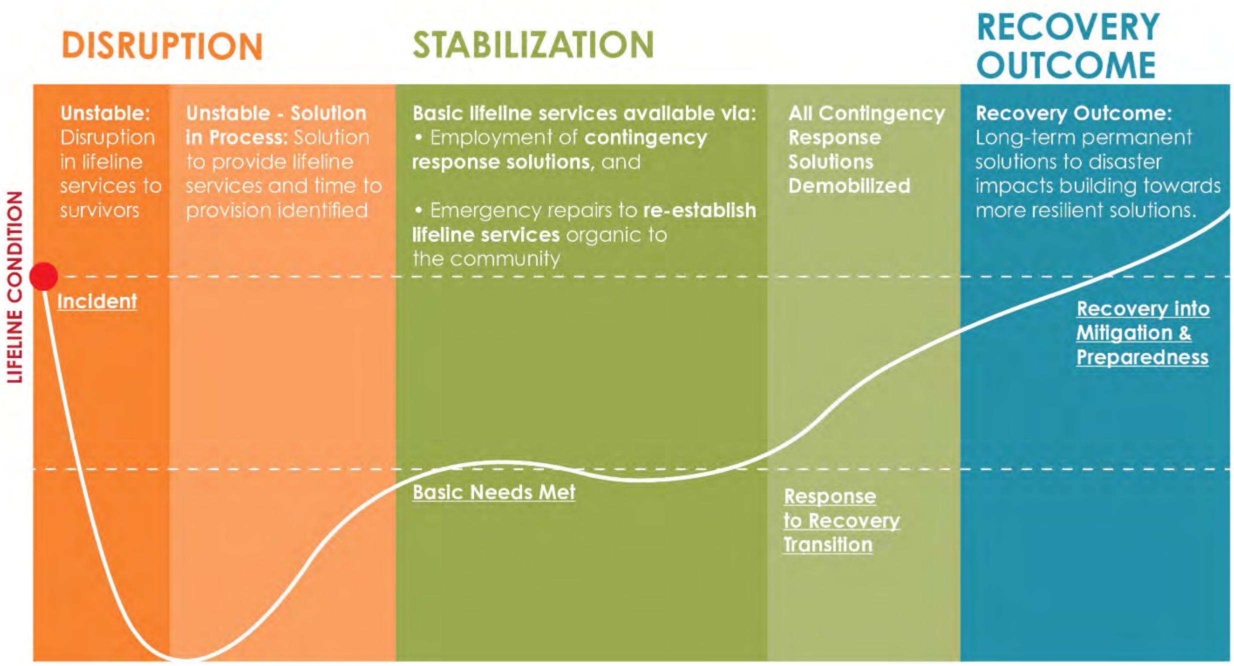

Figure 6. Illustration of disaster recovery phases that lead to the long-term goal of resilience. Source: FEMA Incident Stabilization Guide (Operational Draft). FEMA. November 2019.

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[18] The Natural Hazard Mitigation Saves: 2019 Report is a compilation of latest findings on retrofit strategies with: Natural Hazard Mitigation Saves: 2018, the Interim report, the Natural Hazard Mitigation Saves: Utilities and Transportation Infrastructure, and the Natural Hazard Mitigation Saves: 2017 Interim Report. Accessed at https://cdn.ymaws.com/www.nibs.org/resource/resmgr/reports/mitigation_saves_2019/mitigationsaves2019report.pdf

Mitigation for the Present and Future

As Puerto Ricans look toward their collective future and make decisions about how to mitigate natural and human-caused hazards and instabilities such as hurricanes, flooding, climate change and sea level rise, economic disparity, earthquakes, pandemics, drought, and many others, several organizing principles emerge.

These organizing principles form a common thread throughout the Risk-Based Mitigation Needs Assessment and inform the programmatic response to the mitigation needs identified therein.

- Reduce instability by lessening the impact of hazard events on the built environment, social structures, and ecological systems.
- Improve the adaptive capacity of Puerto Rico by removing impediments to long-term systemic change and promoting collaborative governance at multiple scales.
- Create self-sustaining, regenerative systems that have the ability to persist or thrive through physical, economic and social challenges.

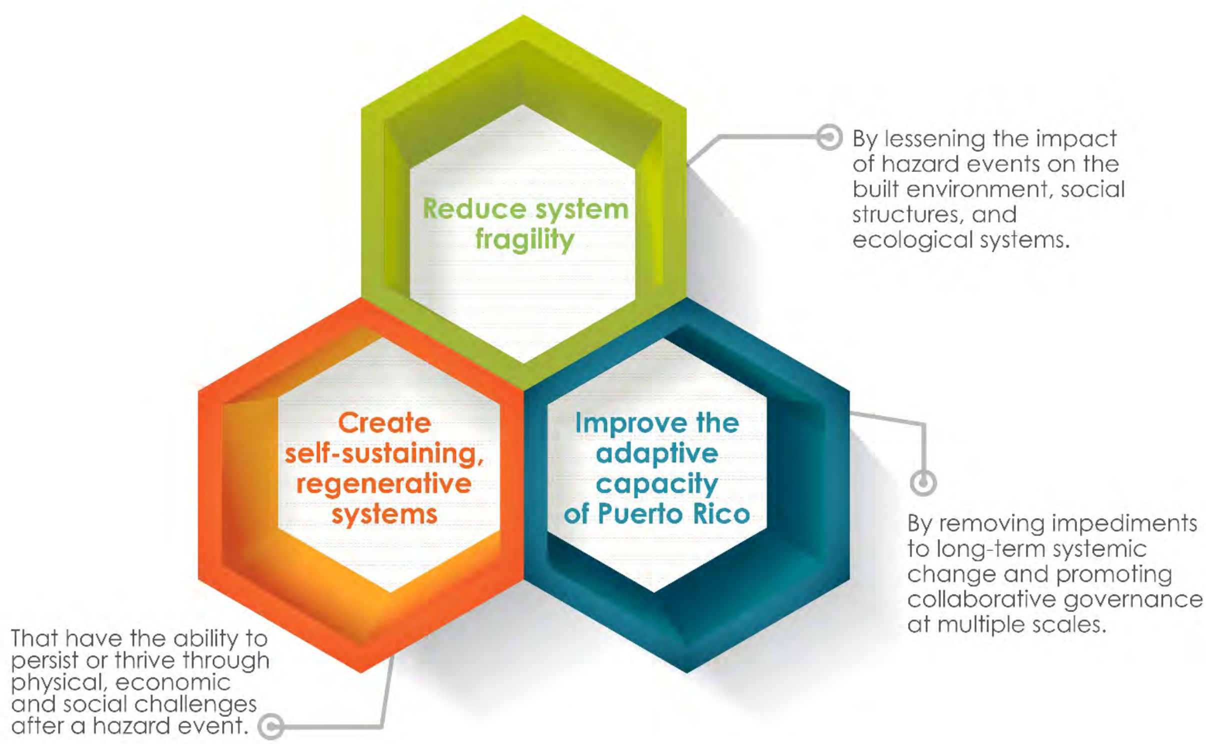

Figure 7. PRDOH CDBG-MIT Organizing Principles

HAZARD ANALYSIS

HAZARD ANALYSIS

PRDOH embraces HUD's design of the CDBG-MIT program to complement in structure the policies and procedures that support FEMA's HMA programs. Consistent with HUD's objectives to align these federally funded mitigation programs for the benefit of disaster-impacted grantees at the local and state levels, PRDOH has consulted, and will continue to engage through ongoing coordination, entities with historic and current involvement in FEMA's HMA[19] programs for Puerto Rico.

In Puerto Rico, those entities with a role in the administration of the FEMA Hazard Mitigation Planning (**HMP**) Program and Hazard Mitigation Grant Program (**HMGP**) include:

Entity	Role
State Emergency Management and Disaster Administration Agency (**AEMEAD**)	Authored the 2016 SHMP approved by FEMA – the Plan which remains in effect today. This entity remains operable but is no longer involved in the administration of FEMA's HMA programs.
Central Office of Recovery, Reconstruction and Resiliency (**COR3**)	Administers the HMGP program for hurricanes and oversees the ongoing update of the state and municipal HMPs. COR3 is the agency with designated FEMA coordination authority in Puerto Rico.
Puerto Rico Planning Board (**PRPB**)	A grant recipient of HMA funds that leads the development of updated HMPs for all seventy-eight (78) municipalities and the state plan.
Government of Puerto Rico Agencies	State agencies that are eligible subrecipients for FEMA HMGP.
Municipalities	Eligible subrecipients for FEMA HMGP and lead authorities for local HMPs.

In preparing the Risk-Based Mitigation Needs Assessment, PRDOH first consulted the plan of record under FEMA authority, as the baseline for understanding the natural and human-caused risks Puerto Rico has historically faced.[20] PRDOH also consulted the PRPB

[19] FEMA's HMA programs include: Hazard Mitigation Planning (HMP) Program, Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance (FMA) program, and now the Building Resilient Infrastructure & Communities (BRIC) Program

[20] HUD states in 84 FR 45840 that CDBG-MIT grantees "…must use the risks identified in the FEMA approved HMP as the starting point for its Mitigation Needs Assessment unless the jurisdiction is in the process of updating the HMP. If a jurisdiction is currently updating an expired HMP, the grantee administering the CDBG–MIT funds must consult with the agency administering the HMP update to identify the risks that will be included in the Mitigation Needs Assessment."

and its vendors involved in completing a full-scale update of the state and all seventy-eight (78) municipal hazard mitigation plans funded as a response the 2017 hurricanes. However, due to the timing of the consultation and the fact that the HMP updates are on a three (3)-year schedule under the FEMA HMP grant, PRDOH was unable to align its analysis with the current state of PRPBs planning efforts. Accordingly, the risk assessment profiled in these pages is based on the latest plan and includes the consideration of efforts to update the state and municipal plans. Additional steps will be taken in the future as all agencies move toward a modernized understanding of risk.

Profile of Historic Events

Puerto Rico 2016 State Hazard Mitigation Plan

As a requirement of the federal law "Disaster Mitigation Act" of 2000 (**DMA 2000**), the Government of Puerto Rico had a State Hazard Mitigation Plan (**SHMP**) prepared under the direction of the Mitigation Division of AEMEAD.[21] At the time of preparing the original CDBG-MIT Action Plan, PRDOH confirmed the SHMP of 2016 as the plan in effect, approved by FEMA and officially adopted by the Government of Puerto Rico on May 18, 2016.[22] The hazard assessment within the SHMP identifies possible physical, economic, and social impacts, to establish a mitigation strategy directed to remove the possibility, or reduce the impact, of emergencies or disasters.[23]

Hazard Profile Affecting Puerto Rico

Hurricanes and Flooding. The 2016 SHMP identifies hurricanes and tropical storms as the most common natural hazard in Puerto Rico that can cause the most extensive damage and loss. These weather events are viewed as the most dangerous because of their potential for destruction, their potential to affect large areas, ability to form spontaneously, and unpredictability. Hurricanes are also often accompanied by other destructive natural events such as high tides, storm surge, and heavy rains that cause landslides and flooding.

The SHMP acknowledges that the Island has tropical rainforests in the Sierra de Luquillo and the Cordillera Central, but semi-arid conditions prevailing in the south and southwest coasts. Average annual rainfall totals range from thirty (30) inches in the southwest portion of the south coast up to 160 inches near the top of El Yunque.

Rain is heaviest on the Island during the months of May through November because of tropical waves, cyclones, and sometimes troughs. These are the months of the year when flooding risks are highest. In the summer months from June to September, when the weather is warmest, the risk of high-frequency atmospheric events such as tropical storms and hurricanes is highest.

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[21] Agencia Estatal para el Manejo de Emergencias y Administración de Desastres (AEMEAD)
[22] Executive Order OE-2016-021.
[23] Page 47 of Puerto Rico Hazard Mitigation Plan, 2016

Historic Hurricane and Flooding Events of Significance [24]	
Event	**Description**
Hurricane San Ciriaco, 1899	This hurricane was one of the most shocking tragedies in terms of loss of life: more than 3,000 people died, mostly drowned. Rainfall was recorded at twenty-three (23) inches in twenty-three (23) hours in the Municipality of Adjuntas.
Hurricane San Felipe, 1928	This hurricane is considered one of the most violent in its effects on Puerto Rico. Estimated death tolls ranged from 300 to 1,000 and many of the crops that supported the economy—coffee, sugar, tobacco—were destroyed.
Hurricane San Ciprián, 1932	This hurricane happened a year after Hurricane San Nicolás (September 1931), when the economy was still in recovery. Two hundred twenty-five (225) people died.
Hurricane Donna, 1960	This hurricane passed over the Island, 100 miles north of San Juan; however, heavy rains caused floods, killing one hundred and seven (107) people in the Municipality of Humacao.
Tropical Depression, 1970	This depression was stationary from October 5 to October 10, 1970. It produced widespread flooding that led to Presidential Disaster Declarations in sixty (60) municipalities. The highest rainfall totals measured in Jayuya were more than thirty-eight (38) inches. There were eighteen (18) deaths and damage quantified over $65 million.
Tropical Storm Eloísa, 1975	This storm caused flooding and landslides that killed thirty-four (34) people and twenty-nine (29) were reported missing. Damage was estimated at $125 million.
Hurricane David and Storm Federico, 1979	These events occurred on August 30 and September 4, 1979, respectively. Both events led to a Presidential Disaster Declaration in seventy-two (72) municipalities and seven (7) people were killed. The federal allocation for individual and Public Assistance totaled $102 million.
Tropical Depression, 1985	In May 1985, there was another Presidential Disaster Declaration as a result of flooding caused by a tropical depression that later became Hurricane Gloria. Two (2) people were killed and damage totaled $37 million.
Tropical Wave - Mameyes Event, 1985	A tropical wave crossed the Island causing flooding in some areas, depositing up to twenty-four (24) inches of rain in twenty-four (24 hours) causing flooding, landslides, and mudflows that interrupted basic services, blocked roads, destroyed bridges, damaged structures, and deposited silt, gravel and debris on the roads. The works of flood control, drainage and irrigation facilities were blocked. The Water and Sewerage Authority and the Electricity Authority suffered significant system damage. This tropical wave left fifty-three (53) people dead from floods; the community of Mameyes was buried because of a landslide killing 127 people and a bridge collapsed killing twenty-nine (29) people. The flow of water that eroded the bridge passed by the Municipality of Coamo destroying more than 600 homes. The water flow was higher than the expected recurrence of a 100-year flood. About five (5) bridges were destroyed, leaving many communities isolated. In addition, seventeen (17) people died in Ponce, as they were washed away by Las Batatas gully. There was a Presidential Disaster Declaration, twenty-eight (28) municipalities were eligible for Individual Assistance and thirty-four (34) municipalities were eligible for Public Assistance, FEMA assistance totaled nearly $264 million.

[24] Source information pulled from the 2016 Puerto Rico Hazard Mitigation Plan. Accessed under file name "Puerto Rico Plan de Mitigación-Aprobado 02/08/2016" at the following website location: https://recovery.pr/en/document-library.

Historic Hurricane and Flooding Events of Significance [24]	
Event	**Description**
Hurricane Hugo, 1989	This hurricane was a Category 4. To the east and northeast of Puerto Rico there was an estimated storm surge of four (4) to six (6) feet in the vicinity of Fajardo and Ceiba. Higher storm surge totals were observed in Vieques and Culebra. There were about ten (10) inches of rain in forty-eight (48) hours causing flooding in the northeastern part of the Island. There were heavy losses in livestock, agriculture, and horticulture recorded; a total of twenty-seven (27) municipalities were eligible to receive federal aid. Damage was estimated at $2 billion. Carraízo Lake Dam suffered a power failure that prevented the floodgates from opening to allow water discharge. The water level rose, reaching the engine room and damaging the pump motors of the dam. These engines pump water to the Sergio Cuevas Filtration Plant, which serves two-thirds (2/3) of the San Juan Metropolitan Area and surrounding municipalities. Water service was restored nine (9) days later.
Flooding of January 5-6, 1992	On January 5, 1992, a cold front, accompanied by a trough in the upper levels of the atmosphere, generated heavy rain and thunderstorms. This caused flash floods that killed twenty-one (21) people, eighteen (18) of whom died in their cars traveling at night, three (3) people went missing, and there was more than $50 million in property damage. Most deaths occurred when people in their cars were swept away by the river or as they were trying to cross rivers beyond their banks.
Hurricane Marilyn, 1995	The Islands of Vieques and Culebra were the hardest hit by this hurricane. An estimated one hundred and twenty (120) homes were destroyed and another eight hundred twenty-nine (829) sustained damage. The waste treatment plant in the Municipality of Culebra was damaged, causing the overflow of the lake which created a potential health risk to the community. The accumulation of debris was estimated at 4,000 cubic yards in Vieques and approximately 10,000 cubic yards in Culebra. Initially, estimated damage was $1.2 million for private residences and $9 million for municipal infrastructure. Twenty (20) deaths and eight (8) injuries were attributed to this disaster. The President signed Disaster Declarations for fourteen (14) municipalities.
Hurricane Hortense, 1996	This hurricane was a Category 1 with winds of eighty-five (85) mph. It caused an estimated $200 million in damage to public and private property and the death and disappearance of twenty (20) people, most of them as a result of flooding. About 10,500 people were displaced to shelters across the Island. Recorded rainfall data exceeded twenty (20) inches in twenty-four (24) hours. In the interior of the Island, rainfall exceeded the expected levels of a 100-year storm. Large tracts of land to the north, east and southeast of Puerto Rico remained under water. Many of the major rivers and its tributaries overflowed. About forty (40) roadways were blocked by flooding and landslides and some bridges collapsed due to the speed of current flow or due to the accumulation of debris.
Hurricane Georges, 1998	This hurricane left a trail of damage as a result of high winds, rains, floods, mudslides and surges. The greatest accumulation of rain occurred in the central mountainous interior causing all rivers to overflow their banks, some of which set record discharges, and many created new channels. The storm surge values were estimated at about ten (10) feet high in the town of Fajardo. Many parts of the West coast experienced severe erosion of the beaches. The seventy-eight (78) municipalities were affected: 3.6 million people without drinking water, 600,000 people without phone service, one hundred percent (100%) of the electrical system was interrupted, 31,000 homeless, 100,000 houses damaged or destroyed, forty (40) bridges and miles of roads damaged or blocked, 2.5 million cubic yards of rubble, ninety-five percent (95%) of the total loss of banana crop, seventy percent (70%) total loss of coffee harvest, and sixty percent (60%) loss of poultry production. The number of refugees rose to 28,000 in 420 shelters spread throughout the Island. The economic impact was estimated at $2 billion.

Historic Hurricane and Flooding Events of Significance [24]	
Event	**Description**
Flooding in November 2003	November 12 to 14, 2003, a trough caused heavy rains on the Island for three (3) consecutive days affecting the south region. Total damages were estimated at $4.3 million. The roads affected were PR-10 from Adjuntas to Ponce, PR-52 at Cayey, and PR-172 that connects Caguas to Cidra. In the town of Moca a woman died after falling off a cliff in her car. Two (2) men died trying to walk across flooded bridges in the municipalities of Aibonito and Ciales. Three (3) bridges collapsed and six (6) others were damaged. A total of 856 people had to be sheltered, forty percent (40%) of the public school system was closed, twenty (20) roads were impassable, 138,174 people were left without drinking water and more than 12,600 families were left without electricity. One hundred percent (100%) of crops were damaged. In the Valle of Lajas many cattle drowned. The Rio Grande of Añasco came out of its banks causing loss of banana crop. President George Bush issued a Presidential Disaster Declaration covering twenty-one (21) municipalities, which qualified for Public Assistance and Individual Assistance.
November 10, 2005	There was a new Presidential Emergency Declaration in Puerto Rico due to severe storms causing landslides and floods across the Island. The most affected municipalities were: Adjuntas, Aibonito, Cayey, Guayanilla, Jayuya, Juana Díaz, Lares, Maricao, Orocovis, Peñnuelas, Ponce, Salinas, Santa Isabel, Utuado, Villalba, Yabucoa and Yauco.
October 1, 2008	Presidential Disaster Declaration (DR-1798) due to severe storms and flooding beginning on September 21, 2008 to October 3, 2008. The most affected municipalities were: Guayama, Humacao, Maunabo, Patillas, Ponce, Salinas, Santa Isabel, and Yabucoa. The total number of residences impacted were over 2,000 and the total assistance cost estimate was $43 million.
June 24, 2010	Presidential Disaster Declaration (DR-1919) due to severe storms and flooding during the period of May 26 to 31, 2010. Ten (10) municipalities were affected: Arecibo, Barranquitas, Coamo, Corozal, Dorado, Naranjito, Orocovis, Utuado, Vega Alta, and Vega Baja. The total Public Assistance cost estimate was of $6 million. This declaration also made Hazard Mitigation Grant Program assistance available for hazard mitigation measures in all municipalities within the Government of Puerto Rico as requested by the Governor
Tropical Storm Otto, October 26, 2010	Presidential Disaster Declaration (DR-1946) due to severe storms, flooding, mudslides, and landslides associated with Tropical Storm Otto during the period of October 4 to 8, 2010. The most affected municipalities were: Adjuntas, Aibonito, Añasco, Guánica, Guayama, Jayuya, Lares, Las Marías, Maricao, Mayagüez, Morovis, Orocovis, Patillas, Ponce, Sabana Grande, Salinas, San Germán, Utuado, Villalba, Yabucoa, and Yauco. $20 million was obligated for Public Assistance.
July 14, 2011	Presidential Disaster Declaration (DR-4004) due to severe storms, flooding, mudslides, and landslides during the period of May 20, 2011 to June 8, 2011. The most affected municipalities were: Añasco, Caguas, Camuy, Ciales, Hatillo, Las Piedras, Morovis, Orocovis, San Lorenzo, San Sebastián, Utuado, and Villalba. Seven point five ($7.5) million was obligated for Public Assistance.
Hurricane Irene, August 22, 2011	Emergency Declaration (EM-3326) due to severe rain, flooding, and landslides caused by Hurricane Irene during the period of June 21 to 24, 2011. The hurricane impacted infrastructure, housing, personal property, and vehicles in twenty-two (22) municipalities: Humacao, Naguabo, Ceiba, Fajardo, Luquillo, Loíza, Carolina, Caguas, Cidra, Cayey, Comerío, Aguas Buenas, Canóvanas, Gurabo, Juncos, Maunabo, San Lorenzo, Yauco, Orocovis, Villalba, Ponce, and Peñuelas.

Historic Hurricane and Flooding Events of Significance [24]	
Event	**Description**
Hurricane Irene, August 27, 2011	Presidential Disaster Declaration (DR-4017) due to severe rain, flooding, and landslides causedlandslides caused by Hurricane Irene during the period of June 21 to 24, 2011. The Disaster Declaration included Individual Assistance for seven (7) municipalities: Caguas, Canóvanas, Carolina, Cayey, Loíza, Luquillo y San Juan. It also included Public Assistance for local government and non-profit organizations in Aguas Buenas, Carolina, Cayey, Ceiba, Comerío, Juncos, Las Marías, Luquillo, Morovis, Naguabo, Orocovis, Utuado, Vega Baja, and Villalba. The total Individual Assistance cost estimate was over $30 million, and the total Public Assistance cost estimate was nearly $5 million, primarily for roads and bridges.
Tropical Storm María, September 2011	Presidential Disaster Declaration (DR-4040) due to severe rain, flooding, and landslides caused by Tropical Storm María during the period of September 8 to 14, 2011. The Disaster Declaration included Individual Assistance for three (3) municipalities: Yabucoa, Juana Díaz, and Naguabo. The total Individual Assistance cost estimate was $7 million.

Landslides caused by heavy rains. The 2016 SHMP explains that many of the landslides that occur in Puerto Rico are in a special category of landslides known as "debris flow" which occurs in mountainous areas with significant slopes during heavy rains. The rain saturates the soil and causes ground level and peel strength loss, usually where the ground makes contact with the bedrock.

Historic Landslide Events of Significance [25]	
Event	**Description**
Tropical Storm Eloísa, 1975	This storm caused flooding and landslides, unspecified damages.
Tropical Wave - Mameyes Event, 1985	From October 4 to October 7, 1985, one of the most catastrophic events in recent decades in Puerto Rico and the United States history occurred, which led to a Presidential Disaster Declaration and federal allocation of $65 million. On this occasion a tropical wave crossed the Island causing flooding in some areas, dumping up to twenty-four (24) inches of rain in twenty-four (24) hours. There were 127 people killed by a landslide in the neighborhood of Mameyes located in the municipality of Ponce. This was an informal community located on a steep slope, which experienced a massive rock release. The soil failed, in part because of the saturation of the ground caused by a leak from a water storage tank located at the top of the slope. This wiped out one hundred (100) homes that were literally buried under layers of earth and rocks. Another tragedy occurred during the night when the slab of a bridge collapsed on the road leading from San Juan to Ponce, on the stretch of Coamo due to soil erosion under one of the columns; about twenty-nine (29) people rushed down the bridge and died.

[25] Source information pulled from the 2016 Puerto Rico Hazard Mitigation Plan. Accessed under file name "Puerto Rico Plan de Mitigación-Aprobado 02/08/2016" at the following website location: https://recovery.pr/en/document-library.

Historic Landslide Events of Significance[25]	
Event	**Description**
Rains in November 2003	Rains caused twenty-one (21) municipalities to be declared disaster areas by Presidential Disaster Declaration. Twenty-six (26) roads were impassable among them; PR-10 between Adjuntas and Ponce was blocked by a landslide of 1,300 cubic meters of mud. On Highway Luis A. Cayey Ferré in Cayey, detachment of a pipe blocked two lanes. A huge wall of forty (40) feet belonging to a housing project (Bairoa Wall) in the Municipality of Caguas collapsed in some areas, endangering the lives of more than a dozen (12) families who lived behind it. A family in the town of Moca became homeless when their three-story house collapsed; the family came out unharmed. The rains caused the ground to give way and split some of the columns, the land deposited outside the residence that gave way consisted of nineteen (19) feet of landfill and rough soil. Several landslides left some communities in the municipality of Utuado isolated; in the development Barriada Nueva thirty (30) houses were in danger of collapsing as the river undermined the land of the local road which faces the residences. In the Monte Verde development, in the municipality of Manati, three (3) families lost their homes in a sinkhole and six (6) other houses sank exposing the vents of other sinkholes. The construction of this development took place between hummocks and a total of eight (8) sinkholes that were fenced by the developer to isolate them from the 500 homes built.
Tropical Storm Jeanne, September 17, 2004	By Presidential Disaster Declaration number 1552, FEMA has provided financing for recovery for the effects of Tropical Storm Jeanne, which caused multiple landslides in virtually the entire Island. A total of seventy-two (72) municipalities received assistance because of this event.
March and April 2008	Rainfall occurred during the months of March and April 2008, causing landslides. The effects of these events impacted the community of Carruzos in Carolina, the community Cerca del Cielo in Ponce, and the community of Unibón in Morovis. The combination of geological, climatological and the inappropriate construction and development practices in urbanized areas, were the main causes for these landslides.
Tropical Storm Otto, October 26, 2010	A Presidential Disaster Declaration (DR-1946) was declared due to severe storms, flooding, mudslides, and landslides associated with Tropical Storm Otto during the period of October 4 to 8, 2010. The municipalities most affected were: Adjuntas, Aibonito, Añasco, Guánica, Guayama, Jayuya, Lares, Las Marías, Maricao, Mayagüez, Morovis, Orocovis, Patillas, Ponce, Sabana Grande, Salinas, San Germán, Utuado, Villalba, Yabucoa, and Yauco. $20 million was obligated for Public Assistance.
July 14, 2011	A Presidential Disaster Declaration (DR-4004) was declared due to severe storms, flooding, mudslides, and landslides during the period of May 20, 2011 to June 8, 2011. The municipalities most affected were: Añasco, Caguas, Camuy, Ciales, Hatillo, Las Piedras, Morovis, Orocovis, San Lorenzo, San Sebastián, Utuado, and Villalba. $7 million was obligated for Public Assistance.

Winds from Tropical Cyclones and Hurricanes. The 2016, SHMP notes that winds caused by hurricanes and tropical cyclones can cause significant damage to buildings and infrastructure because of their intensity and their high velocity winds that can to pick up and release debris, causing it to function as missiles.

Historic Wind Events of Significance [26]	
Event	**Description**
Hurricane San Felipe, 1928	This Category 5 hurricane is considered one of the largest cyclones in the North Atlantic. Maximum sustained winds were 160 mph, with gusts of two hundred (200) mph. It caused extensive private property damage, 312 people died, 83,000 people were without shelter, and it caused $50 million in losses.
Hurricane Hugo, 1989	This Category 4 hurricane passed through San Juan with sustained winds of 125 mph. A Presidential Disaster Declaration was issued in which fifty-seven (57) municipalities were declared eligible for Public Assistance and Individual Assistance. There was one (1) death and damage was estimated at $1 billion.
Hurricane Marilyn, 1995	On September 15, early in the morning, the center of the hurricane passed forty-five (45) miles east-northeast of San Juan with maximum sustained winds of 110 mph. It grew to be a Category 3 hurricane.
Hurricane Hortense, 1996	This hurricane damaged some 4,000 homes. Agriculture suffered severe damage, particularly in the mountainous area. Other damages associated with winds were falling trees, falling utility poles and telephone poles. A Presidential Disaster Declaration was issued covering sixty-seven (67) municipalities.
Hurricane Georges, 1998	This hurricane's 110 mph winds defoliated agricultural areas. About -4.5 million birds died representing sixty percent (60%) of poultry production, and a workforce of thirty-six thousand 36,000 agricultural jobs were affected. Heavy rains and strong winds caused $45 million in damage to roads. Winds defoliated and uprooted trees in forest areas causing an accumulation of vegetative debris, mainly in urban areas. The United States Army Corps of Engineers indicated that the hurricane caused a total of approximately 2.5 million cubic yards of vegetative debris (trees, branches and leaves) equivalent to three (3) fifty (50)-story buildings. The forest areas are classified as critical to the recovery of native and migratory bird species. An estimated 20,000 homes were destroyed, 38,000 homes suffered major damage, 63,000 homes reported minor damage, and - 48,500 were affected. Two (2) days after the Hurricane, 31,500 people were in shelters. Puerto Rico's government estimated the hurricane's economic impact to businesses at $528 million. The government spent $371,500 in Public Assistance to repair damage to its infrastructure. The Presidential Disaster Declaration for seventy-eight (78) municipalities included all categories of disaster relief. It is the first time that all the municipalities of Puerto Rico are included in only one Presidential Disaster Declaration.
Tropical Storm Otto, 2010	The indirect effects of Tropical Storm Otto in October 4 to October 8, 2010, caused flooding and mudslides, a Presidential Disaster Declaration (DR-1946) was issued covering twenty-five (25) municipalities. The municipalities included in the declaration were: Adjuntas, Aibonito, Añasco, Cayey, Ciales, Corozal, Guánica, Guayama, Jayuya, Lares, Las Marías, Maricao, Mayagüez, Morovis, Orocovis, Patillas, Ponce, Sabana Grande, Salinas, San Germán, San Lorenzo, Utuado, Villalba, Yabucoa and Yauco. $20 million has been obligated for Public Assistance.

[26] Source information pulled from the 2016 Puerto Rico Hazard Mitigation Plan. Accessed under file name "Puerto Rico Plan de Mitigación-Aprobado 02/08/2016" at the following website location: https://recovery.pr/en/document-library.

Historic Wind Events of Significance [26]	
Event	**Description**
Hurricane Irene, 2011	A Presidential Disaster Declaration (DR 4017) was declared due to effects caused by Hurricane Irene during the period of June 21 to 24, 2011. The effects of Hurricane Irene included: severe rain, flooding, and landslides. The Disaster Declaration included Individual Assistance for seven municipalities: Caguas, Canóvanas, Carolina, Cayey, Loíza, Luquillo y San Juan. Also included Public Assistance for local government and non-profit organizations in Aguas Buenas, Carolina, Cayey, Ceiba, Comerío, Juncos, Las Marías, Luquillo, Morovis, Naguabo, Orocovis, Utuado, Vega Baja, and Villalba. The total Individual Assistance cost estimate was $30 million and the total Public Assistance cost estimate was nearly $5 million primarily for roads and bridges.
Tropical Storm María, 2011	A Presidential Disaster Declaration (DR-4040) was declared due to sever rain, flooding, and landslides caused by Tropical Storm María during the period of September 8 to 14, 2011. The Disaster Declaration included Individual Assistance for three (3) municipalities: Yabucoa, Juana Díaz, and Naguabo. The total Individual Assistance cost estimate was more than $7 million.

Earthquakes. In the 2016 SHMP, Earthquakes are identified as a high hazard for Puerto Rico due to the irregular time intervals between these events, lack of adequate forecasts, and the catastrophic damage that can occur to building and infrastructure. Earthquake events can also cause other destructive natural events such as liquefaction and landslides. Puerto Rico experiences ongoing seismic activity, most of which is low intensity and therefore not felt by the populace, nor damaging to infrastructure. Until recent events, the history of earthquake damage as reported in the SHMP occurred between 1617 and July 29, 1943.

Based on frequency statistics and recurrence of seismic activity, the SHMP estimates that earthquakes have occurred on the Island with a recurrence of every fifty-seven (57) to one hundred seventeen (117) years (one (1) or two (2) per century). At the time the SHMP was published, the last strong earthquake was in 1918, an indicator of a significant possibility for Puerto Rico to feel another strong tremor of equal magnitude with destructive effects in the next forty (40) years of 2016.

However, it should be noted that each seismic event is generated along a different fault. Therefore, it is difficult to make a prediction on occurrence based on these events alone. In Puerto Rico, vulnerability studies have shown a probability of thirty-three percent (33%) to fifty percent (50%) of vigorous shaking (Intensity VII or more on the Modified Mercalli Scale) for different parts of the Island for a period of fifty (50) years. Most activity has been attributable to the north Trench of Puerto Rico, thirty-seven (37) miles from San Juan city center with a potential to produce earthquakes of magnitudes between eight (8) and eight point two five (8.25) on the Richter Scale.

Historic Earthquake Events of Significance[27]	
Event	**Description**
September 8, 1615	An earthquake in the Dominican Republic caused damage in Puerto Rico.
August 15, 1670	There was a strong earthquake of unknown magnitude that significantly affected the region of San Germán.
Year 1717	An earthquake caused the destruction of the Churches of Arecibo and San Germán.
August 30, 1740	An earthquake of Intensity VII (Modified Mercalli Scale) destroyed the Church of Guadalupe in Ponce.
May 2, 1787	This was probably the strongest earthquake that struck Puerto Rico since the early colonization. It was strongly felt throughout the Island and may have reached a magnitude of 8.0 degrees on the Richter Scale. Its epicenter was possibly the North, in the Puerto Rico Trench. This earthquake demolished the Arecibo church along with the Rosario and Concepción Chapels, churches in Bayamón, Toa Baja and Mayagüez were also damaged. It also caused considerable damage in the San Felipe del Morro and San Cristóbal, where water tanks, walls and guard houses cracked. With the exception of the southern area, the whole island was damaged.
April 16, 1844	An earthquake of intensity VII-VIII (Modified Mercalli Scale) destroyed several buildings and homes, municipalities affected are not specified.
November 28, 1846	An earthquake of unknown intensity was felt throughout the Island; little damage to the northern area was reported.
November 18, 1867	Twenty (20) days after the Island had been devastated by Hurricane Narciso, there was a strong earthquake with a magnitude of about 7.5 degrees on the Richter scale. Its epicenter was located in the Anegada Passage between Puerto Rico and the Island of Santa Cruz. The earthquake caused a tsunami that came about 490 feet inland in low-lying coastal parts of the municipality of Yabucoa. The earthquake caused damage to many buildings in the Island, especially in the East.
December 8 to 9, 1875	Earthquake damage was reported in Arecibo and Ponce, the intensity was not specified.
September 27, 1906	An earthquake, intensity not specified but only described as a great damage on the north coast.
October 11, 1918	The epicenter of this earthquake was located northeast of Aguadilla in the Mona Canyon. The earthquake had a magnitude of 7.5 degrees on the Richter scale and was accompanied by a tidal wave or tsunami. The damage was concentrated in the area west of the Island as this was the closest to the epicenter. The earthquake killed approximately 116 people and caused over $4 million dollars in losses. Many houses, factories, public buildings, chimneys of the sugar industry, bridges and other buildings were severely damaged.
July 29, 1943	An earthquake of magnitude 7.3 on the Richter scale was felt in the northeastern part of the Island, damages not specified.
August 4, 1946	An earthquake in the Dominican Republic caused damage to the western part of Puerto Rico.

[27] Source information pulled from the 2016 Puerto Rico Hazard Mitigation Plan. Accessed under file name "Puerto Rico Plan de Mitigación-Aprobado 02/08/2016" at the following website location: https://recovery.pr/en/document-library.

Drought. According to the 2016 SHMP, Puerto Rico does not experience extreme drought conditions with relative frequency. However, there have been important events that have negatively impacted agriculture and have required drastic measures such as water rationing and the introduction of emergency measures such as the distribution of drinking water to affected communities.

The severity of drought events is acknowledged to depend on the degree of impairment in humidity levels, the duration and size of the drought event, and the affected area. The main cause of any drought is the lack of rain or precipitation, called meteorological drought, and if it lasts, can lead to a hydrological drought characterized by a disparity between the natural availability of water and natural water demands. Drought events that last for weeks or longer can have disastrous consequences for agriculture and can lead to the rationing of potable water.

Important Drought Periods [28]	
Event	**Description**
May 26, 1964	Presidential Disaster Declaration Number 170 due to extreme drought conditions.
August 29, 1974	Presidential Emergency Declaration Number 3002 due to drought impacts.
Drought 1994	According with the data, Puerto Rico began experiencing a decrease of thirty-five percent (35%) in the normal amount of rain since August 1993. The decrease of rain fluctuationed, but it sharpened between April and July, 1994, when a fifty-six percent (56%) of normal rain was registered for the Central East region where the reservoir of the Rio Grande de Loíza (Represa Carraízo) and Río La Plata (Represa La Plata) are found. This drought impacted fifty-five percent (55%) of Puerto Rico and it was necessary to implement the rationing of the water service in twenty-nine (29) municipalities. The rationing of water began on April 5, 1994 and it ended in September 1994 because of heavy rains that increase the reservoir levels. This drought had a negative impact in the economy of Puerto Rico, particularly in agriculture with a gross income loss estimate of $93.9 million.
Drought 2015	This drought started in March 2015 when PRASA gave its first warning on the necessity of saving water since the reservoirs were decreasing their levels. In May, the *U.S. Drought Monitor*, classified twelve (12) municipalities under Moderate Drought and forty (40) municipalities were declared as Abnormally Dry. This caused a negative impact in agriculture, rivers, basins, and wells. To address the situation, PRASA developed a Rationing Plan that had three (3) phases: Phase One (1): water in alternate days, Phase Two (2): one (1) day with water and two (2) without, and Phase Three (3): one (1) day with water and three (3) without.

[28] Source information pulled from the 2016 Puerto Rico Hazard Mitigation Plan. Accessed under file name "Puerto Rico Plan de Mitigación-Aprobado 02/08/2016" at the following website location: https://recovery.pr/en/document-library.

Tsunamis. The 2016 SHMP notes that Tsunamis are most common in open sea, but can reach land with severe physical impact and flooding. These events are generally caused by earthquakes, underwater landslides, or volcanic eruptions.

The seismic history of Puerto Rico and the Caribbean region provides valid data to expect tsunamis to occur again. Coastal areas are, in general, at higher risk because they are closer to the submarine fault, have greater exposure to the occurrence of tsunamis; the seismic waves are more amplified and have greater potential for liquefaction in sandy coast areas. Recorded seismic activity indicates that the probability of the Municipality of San Juan of being affected by an earthquake or tsunami is low. The severity level of the wave entering the coastal zone is between 120 to 150 meters in the low places.

Significant Tsunami events[29]	
Event	**Description**
November 18, 1867	An earthquake generated a tsunami that struck southeast Puerto Rico, which was preceded by the sea retreating 150 meters. Then the sea came inland the same distance. The sea came up several feet in some places along the coast, penetrated nearly 150 meters in the lower parts of the coast in the Municipality of Yabucoa.
October 11, 1918	An earthquake in Puerto Rico generated a tsunami wave which reached six (6) feet in northeastern Puerto Rico, but was almost undetectable in San Juan. This tsunami occurred minutes after the earthquake. Before the tsunami, the ocean receded hundreds of feet and then came inland more than 120) meters in some lower areas. In Aguadilla it killed forty (40) people and destroyed nearly 300 homes that were located near the beach. In total 116 people died and property damage exceeded $4 million.
August 8, 1946	There was an earthquake in Mayaguez and Aguadilla of magnitude 7.4 on the Richter scale, damages are not specified.

Climate Change. The 2016 SHMP identifies climate change as an area of scientific research analyzing the relationship between rising global temperatures and the effect on the polar caps melting, thus increasing sea levels and threatening coastal areas in all countries. The SHMP also acknowledged a 2005 study by the Organization for Economic Cooperation and Development based in Paris, France, in which research suggested the City of San Juan, Puerto Rico ranked number sixty-five (65) of a total of 136 cities in terms of population exposed to floods.

Hazards Caused by Humans. The 2016 SHMP identifies human hazards as technological hazards and terrorism caused by human activity rather than a natural event. Human-caused disasters can be the result of an accident or an intentional and malicious act. According to a Federal Bureau of Investigations (**FBI**) report published in 1987, during the period of 1983 to 1987, there were eighty-two (82) incidents of terrorism in the United States, of which thirty-four (34) (representing forty-one point five percent (41.5%))

[29] Source information pulled from the 2016 Puerto Rico Hazard Mitigation Plan. Accessed under file name "Puerto Rico Plan de Mitigación-Aprobado 02/08/2016" at the following website location: https://recovery.pr/en/document-library.

occurred in Puerto Rico.[30] According to the report, of the six (6) cities with the highest incidence of terrorist attacks in the United States, two (2) were in Puerto Rico, Mayagüez and Río Piedras.

Human Caused Hazards[31]	
Event	**Description**
October 17 to 18, 1979	Bombs in various US government facilities, throughout the Island.
January 12, 1981	Bomb destructions of nine A-7 aircraft and damaged two other properties of the Puerto Rico National Guard facilities at Muñiz Base.
November 11 and 27, 1981	Bombs on substations owned by the Puerto Rico Electric Power Authority with losses totaling $4 million.
May 25, 1987	Explosions in four locations across the Island (Western Mayaguez Federal Bank, New York Department Store in Caguas, Ponce U.S. Customs Service and U.S. Postal Service in Aibonito).
November 21, 1996	Presidential Emergency Declaration (EM-3124) due to gas explosion by propane leak in a building located in Ríio Piedras, in which there were multiple injuries to life and property. The explosion left a toll of 33 dead and 69 wounded.
October 24, 2009	Presidential Emergency Declaration (EM 3306) due to explosions and fires in fuel storage facilities of the company CAPECO in the town of Cataño, during the period of October 23 to 26, 2009. This emergency declaration included the municipalities of Bayamón, Cataño, Guaynabo, San Juan, and Toa Baja.

[30] US Department of Justice, Federal Bureau of Investigation, *Terrorism in the United States*, National Memorial Institute for the Prevention of Terrorism in Oklahoma City, 1987.
[31] Source information pulled from the 2016 Puerto Rico Hazard Mitigation Plan. Accessed under file name "Puerto Rico Plan de Mitigación-Aprobado 02/08/2016" at the following website location: https://recovery.pr/en/document-library.

HAZARD FREQUENCY ASSESSMENT

Building on the Existing Research

The analysis in this Action Plan considers the data and hazards profiled in the approved 2016 SHMP (as described in the prior section) and includes additional updated data gathered to consider some of Puerto Rico's most catastrophic historical events including Hurricane Irma, Hurricane María, and seismic activity of significant degree that has been felt by residents since December of 2019.

The hazard frequency assessment also broadens the perspective on hazards present in Puerto Rico by analyzing a total of eighteen (18) hazard events common in US disaster event history and likely in the tropical climate of Puerto Rico. The result is a broader analysis and increased understanding of the types of hazards that may pose threat to Puerto Rico communities and citizens.

Rationale for Hazard Frequency Assessment

A complete risk assessment has four (4) basic components, including: hazard identification; profiling of hazard events; inventory of assets; and an estimate of potential human and economic losses based on exposure and vulnerability of people, buildings, and infrastructure.[32]

This section of the report utilizes the DHS extended risk definition.[33] Here, risk is the potential for an adverse outcome assessed as a function of threats, vulnerabilities, and consequences associated with an incident, event, or occurrence. This Hazard Analysis coupled with the subsequent Risk Analysis portion of this draft together are partitioned into four (4) discrete sections strictly following DHS guidance: Threat Assessment, Vulnerability Assessment, Severity of Consequences Assessment, and the combination of these three (3) resulting in Risk Assessment. A focus first on hazard identification and frequency analysis, for the whole of Puerto Rico, with an emphasis on utilizing the most appropriate data, methods, and analytic tools to meet rapid turn-around CDBG-MIT timelines, provides the basis from which sound planning and mitigation decisions can be made. This report is intended for CDBG-MIT risk assessment informational and planning purposes only. A rigorous geospatial approach and a deep understanding of hazards geography are utilized in the following analytics and associated results. Connecting empirically based hazard assessments with vulnerability, infrastructure at risk, and severity of consequences information, provides a more holistic view of risks across the Island of Puerto Rico.

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[32] United States. FEMA. ***Hazard Mitigation Planning***. https://www.fema.gov/hazard-identification-and-risk-assessment

[33] DHS Risk Lexicon, Department of Homeland Security. September 2008. Accessed at: https://www.dhs.gov/xlibrary/assets/dhs_risk_lexicon.pdf

Methodology

Many hazard analytics processes in this assessment and spatial-analytic processes are adapted from previous risk assessment procedures in several states[34, 35] and regional[36] local mitigation planning documents. Several processes have been specifically altered to reflect Puerto Rico's location closer to the equator (hurricane hazard) and mountainous terrain (landslide hazard). Data specific to Puerto Rico for each hazard analyzed herein (see table below) has been carefully reviewed to ensure data quality in several respects. These include:

- Spatial – does the data adequately reflect all of Puerto Rico;
- Temporal – does the data provide an appropriate timeframe for understanding current and future risks; and
- Numerical – Is the data free from incomplete or inconsistent records?

The results of this analysis have been mapped using geographic information system (**GIS**) tools that allow for visualization of complex spatial data as one of the following data types:

- Point data –a defined point on a map;
- Grid data – a network of evenly spaced horizontal and vertical lines used to identify locations on a map; and
- Polygon – the depiction of data by drawing an outline shape for a spatial feature.

Hazards Analyzed in This Report, in Order of Priority of Analysis[37]

Hazard	Data Type	Period	Temporal/Spatial Resolution	Methods	Dataset and/or Source*
Flood (100 year)	Polygon	-	Time independent	Modeled inundation of 100-year flood	FEMA
Hurricane	Point	1985-2014	6-hourly	Average times per year an area can expect to experience hurricane-force winds 34 kt	HURDAT, CIRA, CSU
Landslide	Grid	-	Various grid cell sizes	Average landslide susceptibility index in any given area	US Geological Survey
Severe Storm	Polygon	2002-2017	Yearly	Average number of times per year an area can	Iowa State University's

[34] South Carolina Hazard Mitigation Plan. State of South Carolina. October 2018 Update. Accessed at: https://www.scemd.org/media/1391/sc-hazard-mitigation-plan-2018-update.pdf

[35] Enhanced State Hazard Mitigation Plan. State of Florida. 2018. Accessed at: https://www.floridadisaster.org/globalassets/dem/mitigation/mitigate-fl--shmp/shmp-2018-full_final_approved.6.11.2018.pdf

[36] An All Natural Hazard Risk Assessment and Hazard Mitigation Plan for the Central Midlands Region of South Carolina. State of South Carolina. 2010 Update. Accessed at: https://centralmidlands.org/freedocs/HMPforadoption-WithRevisions.pdf

[37] Priority of analysis determined by Puerto Rico Hazard Mitigation Plan - https://recovery.pr/en/document-library

Hazards Analyzed in This Report, in Order of Priority of Analysis [37]					
Hazard	**Data Type**	**Period**	**Temporal/Spatial Resolution**	**Methods**	**Dataset and/or Source***
				expect to be under a severe thunderstorm warning	Environmental Mesonet
Storm Surge	Grid	-	Time independent/ 30 m	Modeled inundation of storm surge from a Category-1 hurricane	SLOSH, NOAA
Earthquake	Polygon	-	Time independent	Peak ground acceleration with a 2% probability of exceedance in 50 years	USGS
Drought	Polygon	2000-2017	Weekly	Average number of weeks in drought per year	USDM
Wind	Point	1987-2017	Daily	Average number of days per year with winds above 30 knots	GHCN, NCEI, NOAA
Fog	Point	1987-2017	Daily	Average number of fog days per year using weather station interpolation	GHCN, NCEI, NOAA
Hail	Point	1987-2017	Yearly	Average number of reported hail events per year	SPC, NOAA
High Temperature	Point	1987-2017	Daily	Average number of days where the daily maximum is above 100° 0F	GHCN, NCEI, NOAA
Lightning	Grid	1986-2012	Yearly/4 km	Average number of cloud-to-ground lightning flashes per year	NCEI, NOAA
Tornado	Polygon	2002-2017	Yearly	Average number of times per year an area can expect to be under a tornado warning	Iowa State University's Environmental Mesonet
Wildfires	Polygon	1980-2016	Yearly	Probability of an acre or more burning if ignited	Federal Fire Occurrence webpage, USGS
***CIRA, CSU = Cooperative Institute for Research in the Atmosphere - Colorado State University; GHCN = Global Historical Climatology Network; HURDAT = The Hurricane Database; NCEI = National Centers for Environmental Information; NOAA = National Oceanic and Atmospheric Administration; SLOSH = Sea Lake and Overland Surge from Hurricanes; SPC = Storm Prediction Center; USDM = U. S. Drought Monitor; USGS = U. S. Geological Survey**					

A 0.5-square-mile hexagonal grid is used in this assessment because it provides the best coverage for small spatial areas, such as Cataño Municipality, while providing an ability to visualize spatial differences across the Island as a whole (see figure of hexagonal grids on next page). Summarizing underlying spatial data to the 0.5-square-mile grid cell provides a specific set of information that will be different than using a different sized grid cell. Different grid sizes will yield different results.

Hexagonal grids represent a simplified method to display complex geospatial information.[38] in an approachable way that also allows for aggregation of the data.[39]. Using regular spatial bins (hexagons) serves three (3) primary goals: First, it simplifies data sets and aids in visual communication of complex data. If done correctly, visual binning can enable readers to make reasonable count or density estimates that would otherwise be impossible because of the complexity of underlying data. Second, spatial binning shows a smooth surface of aggregated values across larger areas. Finally, a standardized regular gridded framework, such as the hexagonal grids used here, enables analysis and evaluation within and between datasets that would normally be difficult (or impossible) to visually, statistically, or spatially compare.

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[38] Tableau. "Data Map Discovery: How to use spatial binning for complex point distribution maps". Accessed at: https://www.tableau.com/about/blog/2017/11/data-map-discovery-78603

[39] ResearchGate. "Shapes on a plane: evaluating the impact of projection distortion on spatial binning". Accessed at: https://www.researchgate.net/publication/303290602_Shapes_on_a_plane_evaluating_the_impact_of_projection_distortion_on_spatial_binning

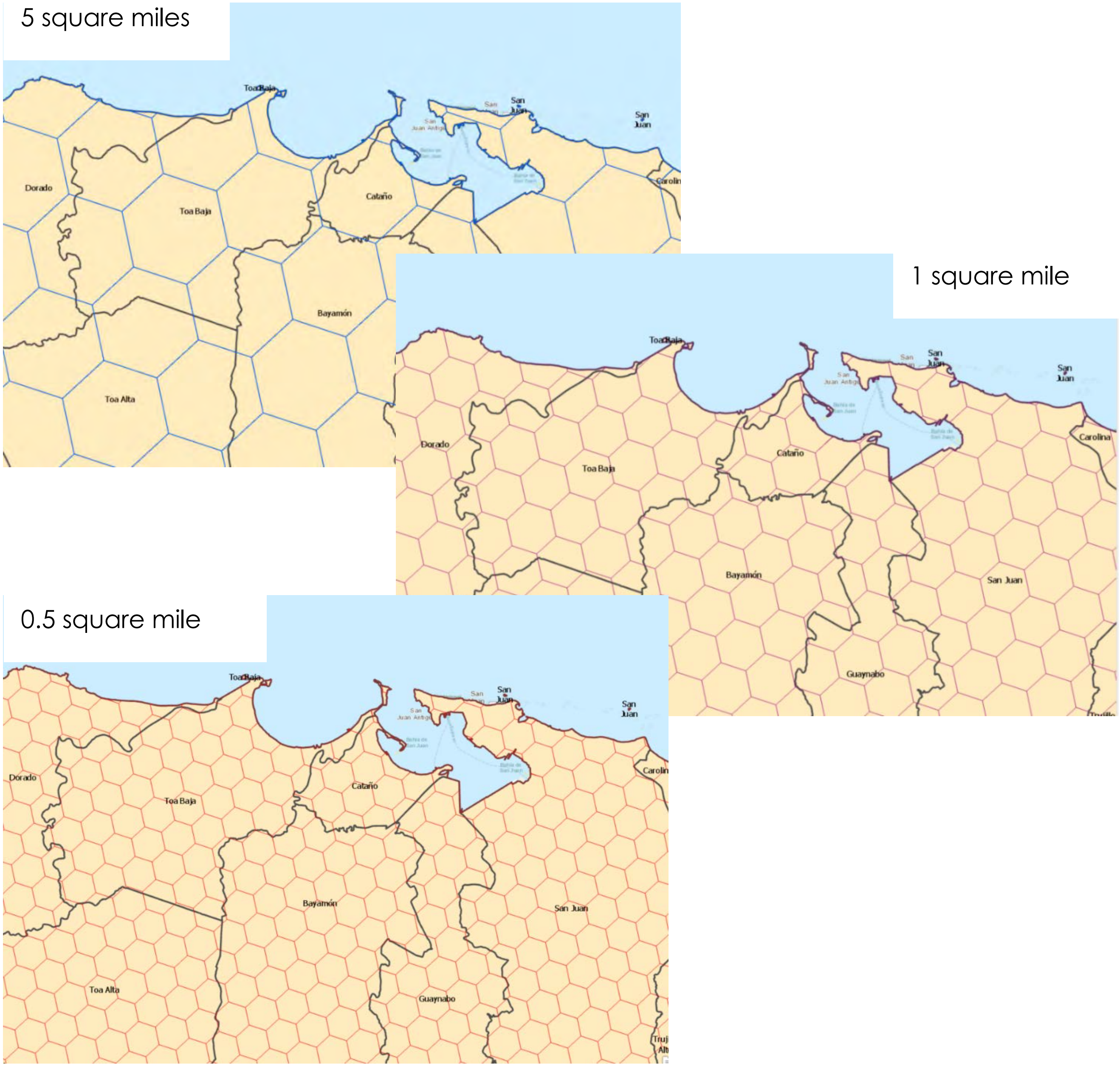

Figure 8. Comparison of Hexagonal Grids for Puerto Rico

Assessment Report Format

The analysis and associated outputs of this report are not intended to replace more detailed, multi-year risk assessment processes such as updating FEMA-required risk assessments and mitigation plans. A geospatial analytics focus on hazard geographies forms the basis of the current assessment. As such, each hazard section provides the following standardized information:

1. Overview of Hazard. Where applicable, background material on hazards is adapted from Puerto Rico's current HMP.[40]. A brief background is provided if a hazard has not been cataloged in Puerto Rico's HMP.
2. Data and Methods. General descriptions of data and methods are provided for reference.
3. Hazard Frequency Analysis Results. An overview of hazard frequency across Puerto Rico including:
    a. Maps of hazard zones. Hazard categories for each hazard type are provided showing frequency of occurrence or other hazard zone/category information for each municipality.
    b. Tables of land area impacted. Three distinct tables are provided each showing results from slightly different perspectives.
        i. Land area in each municipality/hazard zone/category combination.
        ii. Percentage of municipality land area in each municipality/hazard zone/category combination.
        iii. Percentage of total Island land area in each municipality/hazard zone/category combination.
        iv. Standardized hazard score for each municipality. Utilizing the hexagonal grid enables a relative comparison of hazard zones for each municipality. A score for each hazard category (1 - Low to 5 - High) was created by first calculating the percentage of total Island land area in each "zone" in comparison to total Island land area.
        v. The table on the following page titled "Example of Hazard Scoring Step 1, Calculating Percentage Area for Each Category" provides an example (based on severe storm hazard) showing that Adjuntas Municipality has (.88%) of the total island-wide land area in the 'Low' severe storm category, another (1.01%) in 'Medium Low', (.05%) in 'Medium' andin no land in 'Medium High' or 'High' categories.

[40] 2016 Puerto Rico Hazard Mitigation Plan. Accessed under file name "Puerto Rico Plan de Mitigación-Aprobado 02/08/2016" at the following website location: https://recovery.pr/en/document-library.

Example of Hazard Scoring Step 1, Calculating Percentage Area for Each Category					
Municipality	**Severe Storm Percentage of Total (Island) Land Area**				
	Low	Medium Low	Medium	Medium High	High
Adjuntas	0.88%	1.01%	0.05%	0.00%	0.00%
Aguada	0.00%	0.00%	0.83%	0.07%	0.00%
Aguadilla	0.00%	0.00%	1.05%	0.00%	0.00%
Aguas Buenas	0.00%	0.25%	0.62%	0.00%	0.00%
Aibonito	0.73%	0.17%	0.01%	0.00%	0.00%
Anasco	0.00%	0.03%	0.43%	0.42%	0.26%
Arecibo	0.25%	1.74%	1.68%	0.00%	0.00%
Arroyo	0.00%	0.07%	0.37%	0.00%	0.00%
Barceloneta	0.00%	0.50%	0.04%	0.00%	0.00%

Each of these municipality/hazard category combinations is then "normalized" to a zero to one (0-1) scale using a min/max scaling technique. In this approach, the data is scaled to a fixed range of zero (0) to one (1). Min-Max scaling is accomplish using the following equation:

$$Xsc = \frac{X - Min\ X}{Max\ X - Min\ X}$$

Resulting values represent a minimum score of (0) zero to a maximum of (1) one for each hazard zone category and each municipality. There are several ways to represent how hazardous a particular area is. One (1) is called straight line in which we simply assign a number to the level of hazard without considering any other factors, or weighting, that number. Another is called interval (zero to five (0-5)) multiplicative weighting. The problem with these two (2) systems is that, in places where there is a lot of geographic area with "Medium High" hazard risk, giving a higher number than someplace with a smaller geographic area, but a higher hazard risk. This could confuse results and the actions that follow. Instead, we decided to use logarithmic weighting which codifies an increased threat in higher hazard areas over lower hazard areas. Values are converted to a log-multiplied score where the 'Low' score is multiplied by 1 (one), the 'Medium Low' score is multiplied by 10 (ten), the 'Medium'score multiplied by one hundred (100), the 'Medium High' score multiplied by one thousand (1,000), and the 'High' score by ten thousand (10,000). Then, the scores are rescaled to zero to one (0-1) using the mix/max scaling procedures used above. See examples in the table titled "Example of Hazard Scoring Step 2, Calculating Min/Max Values for Each Category" on the following page.

Example of Hazard Scoring Step 2, Calculating Min/Max Values for Each Category							
Municipality	**Min/Max of Severe Storm Percentage of Total (Island) Land Area**					**Log Multiplier Score**	**Severe Storms Score**
	Low	Medium Low	Medium	Medium High	High		
Adjuntas	0.39	0.58	0.02	0.00	0.00	22.62	0.0002
Aguada	0.00	0.00	0.26	0.09	0.00	1172.07	0.0111
Aguadilla	0.00	0.00	0.33	0.01	0.00	390.16	0.0037
Aguas Buenas	0.00	0.14	0.20	0.00	0.00	197.32	0.0019
Aibonito	0.32	0.10	0.00	0.00	0.00	4.13	0.0000
Anasco	0.00	0.02	0.14	0.57	0.18	23987.60	0.2268
Arecibo	0.11	1.00	0.53	0.00	0.00	542.33	0.0051
Arroyo	0.00	0.04	0.12	0.00	0.00	117.30	0.0011
Barceloneta	0.00	0.29	0.01	0.00	0.00	14.92	0.0001

100-year Flooding

Hazard Overview

Flooding is the most frequent and costly natural hazard in the United States. Floods are generally the result of excessive precipitation and can be classified under two (2) categories: flash floods, the product of heavy localized precipitation in a short time period over a given location; and general floods, caused by precipitation over a longer time period and over a given river basin. The severity of a flooding event is determined by a combination of stream and river basin topography and physiography, precipitation and weather patterns, recent soil moisture conditions and the degree of vegetative clearing. Flash flooding events usually occur within minutes or hours of heavy amounts of rainfall, from a dam or levee failure, or from a sudden release of water held by an ice jam. Most flash flooding is caused by slow-moving thunderstorms in a local area or by heavy rains associated with hurricanes and tropical storms. Although flash flooding occurs often along mountain streams, it is also common in urbanized areas where much of the ground is covered by impervious surfaces. General floods are usually longer-term events and may last for several days. The primary types of general flooding include riverine flooding, coastal flooding and urban flooding. Riverine flooding is a function of excessive precipitation levels and water runoff volumes within the watershed of a stream or river. Coastal flooding is typically a result of storm surge, wind-driven waves, and heavy rainfall produced by hurricanes, tropical storms, and other large coastal storms. Urban flooding occurs where man-made development has obstructed the natural flow of water and/or decreased the ability of natural groundcover to absorb and retain surface water runoff.

Data and Methods

FEMA provides a national flood hazard dataset for the US through an online Map Service Center (**MSC**). Accordingly, the entire US Special Flood Hazard Area (**SFHA**) dataset was downloaded, which represents flood hazards with a 0.01 probability of occurrence in any given year, commonly referred to as a 100-year flood or the one percent (1%) annual chance of flooding. Though additional flood zones exist for many locations in the US, depicting the 0.002 chance (500-year) of flooding or areas that may experience high velocity floodwater flows, we utilize only the 100-year SFHA data in our composite hazard analysis. In the case of Puerto Rico, Preliminary 100-year Flood Zones, provided by PRPB, were spatially intersected with Puerto Rico's 0.5-square-mile hexagonal grid to produce a spatial representation of flood hazard across the Island.

Hazard Frequency Analysis Results

Flood hazard potential is present in every municipality, but is significantly more pronounced along the north central, northeastern, eastern, south central, south east, and western municipalities. The 100-Year Flood Zone map on the following page categorizes each 0.5-square-mile hex grid based on the amount of land area it has inside the FEMA Preliminary 100-Year Flood Zone using equal interval classification. Unlike simply using the flood zone perimeter, this map allows for areal comparison across the Island. The northwestern municipalities appear to have relatively less flood hazard potential than most of the other enumeration units across the Island. Additionally, inland municipalities such as Caguas, Gurabo, and Juncos have more areas at flood risk than most other inland neighbors.

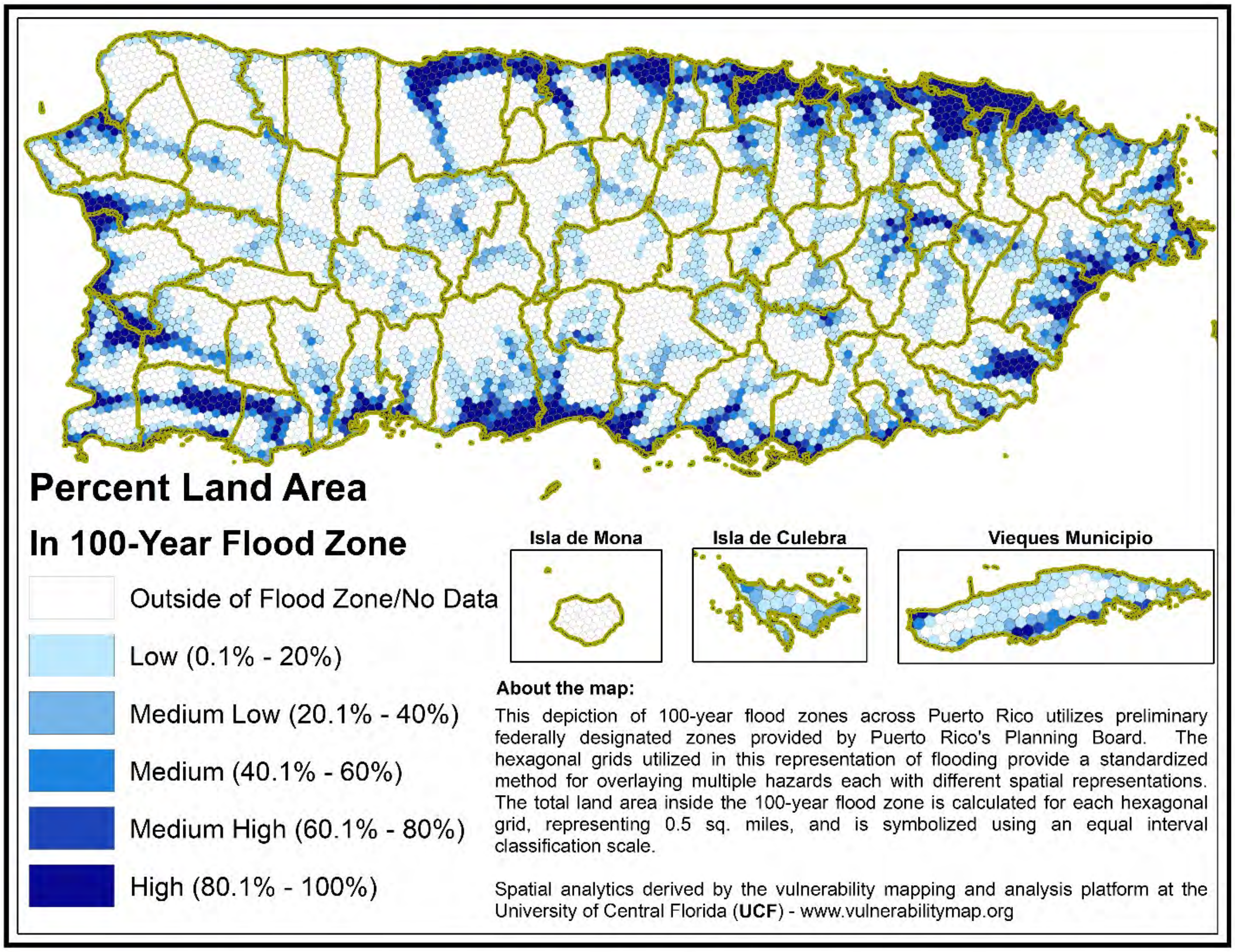

Figure 9: 100-Year Flood Zone Hazard Areas

Hurricane Force Winds

Hazard Overview

Hurricanes and tropical storms are the most common natural hazard in Puerto Rico, causing extensive damage and loss. Hurricanes are tropical weather systems with a higher intensity of sustained winds at seventy-four (74) mph or greater. They develop over warm waters and are caused by the instability created by the collision of warm and cool air. A hurricane is a type of tropical cyclone. Tropical cyclones are classified according to the intensity of their sustained winds, namely:

1. Tropical Depression: An organized system of clouds with a defined circulation and maximum sustained winds which are less than thirty-nine (39) miles per hour. It is considered a tropical cyclone in its formative stage.
2. Tropical Storm: An organized system of clouds with a defined circulation and maximum sustained winds that fluctuate between thirty-nine (39) and seventy-three (73) miles per hour.
3. Hurricane: A maximum intensity tropical cyclone at which the maximum sustained winds reach or exceed seventy-four (74) miles per hour. It has a definite center

with a very low barometric pressure in it. Hurricanes are classified into categories ranging from one (1) to five (5), and winds can reach over 155 miles per hour.

Hurricanes are dangerous because of their potential for destruction, their ability to affect large areas, their ability to form spontaneously, and their unpredictable movement. Hurricanes are often accompanied by high tides, storm surges, and heavy rains that can cause landslides and flooding by swollen rivers.

As an emerging hurricane develops, barometric pressure at its center falls and winds increase. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed thirty-nine (39) miles per hour, the system is designated a tropical storm, given a name and closely monitored by the National Hurricane Center in Miami, Florida. When sustained winds reach or exceed seventy-four (74) miles per hour, the storm is deemed a hurricane. Hurricane intensity is further classified by the Saffir-Simpson Scale, which rates hurricane intensity on a scale of one (1) to five (5), with five (5) being the most intense. The Saffir-Simpson hurricane wind scale[41] categorizes hurricane intensity linearly based upon maximum sustained winds, barometric pressure and storm surge potential, which are combined to estimate potential damage.

Category	Sustained Winds	Types of Damage Due to Hurricane Winds
1	74-95 mph 64-82 kt 119-153 km/h	**Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph 83-95 kt 154-177 km/h	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111-129 mph 96-112 kt 178-208 km/h	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130-156 mph 113-136 kt 209-251 km/h	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	157 mph or higher 137 kt or higher 252 km/h or higher	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Figure 10: Saffir-Simpson Hurricane Wind Scale. Source: NOAA

Categories three to five (3 – 5) hurricanes are classified as “major hurricanes”, and while hurricanes within this range comprise only twenty percent (20%) of US total tropical cyclone landfalls, they account for over seventy percent (70%) of the damage in the US. Damage during hurricanes may also result from spawned tornadoes and inland flooding associated with heavy rainfall that usually accompanies these storms.

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[41] United States. NOAA, National Hurricane Center and Central Pacific Hurricane Center. Accessed at: https://www.nhc.noaa.gov/aboutsshws.php.

Data and Methods

Gaining perspective on historical frequencies of sustained hurricane-force wind speeds across Puerto Rico required a multi-step geospatial process. First, we downloaded Extended Best Track (**EBT**) data for all Atlantic tropical cyclones from the National Hurricane Center.[42]. The National Hurricane Center (**NHC**) maintains a climatology of all Atlantic tropical cyclones since 1851, called HURDAT.[43]. For each storm, HURDAT contains estimates of the latitude, longitude, one (1)-minute maximum sustained surface winds, minimum sea-level pressure, and an indicator of whether the system was purely tropical, subtropical, or extra-tropical, at six (6)-hour intervals. However, HURDAT lacks any information about storm structure. By supplementing HURDAT with additional storm parameters determined by NHC, we created the "extended" best track file. The additional parameters include the following:

1. The maximum radial extent of thirty-four (34), fifty (50) and sixty-four (64) kt wind in four (4) quadrants
2. The radius of maximum wind
3. Eye diameter (if available)
4. Pressure and radius of the outer closed isobar

This EBT data was subset for Puerto Rico, resulting in a set of more than 624 six (6)-hour locations for seventy-seven (77) tropical cyclones close enough to Puerto Rico to impact the Island with winds (see upper left quadrant of image on next page) between 1988 – 2018. The radius to maximum winds for each point was used to create a buffer around each point showing the most likely hurricane wind field. This fan-shaped buffer (see upper right quadrant of image on next page), created specifically for this assessment, accounts for the general movement of hurricanes in this part of the Caribbean. Because most hurricanes travel in an East – West or Southeast – Northwest tract, compared to the more North-South pattern seen in the Southeastern US, the resulting winds associated with these storms are not on the east side of the storm generally, but rather on the north east. Each of the wind fields is then summarized to recreate a specific wind zone polygon for each hurricane event (see bottom left quadrant of image on next page) so that each storm is only counted once in the analytic process. Finally, a sum of the number of hurricanes impacted Puerto Rico between 1988 – 2018 is generated for each hex grid and summarized by municipalities (see lower right quadrant of image on next page).

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[42] United States. Department of Commerce. "Extended Best Track Dataset. Accessed at http://rammb.cira.colostate.edu/research/tropical_cyclones/tc_extended_best_track_dataset/.

[43] HURDAT is a commonly used acronym that stands for the North Atlantic Hurricane Dataset

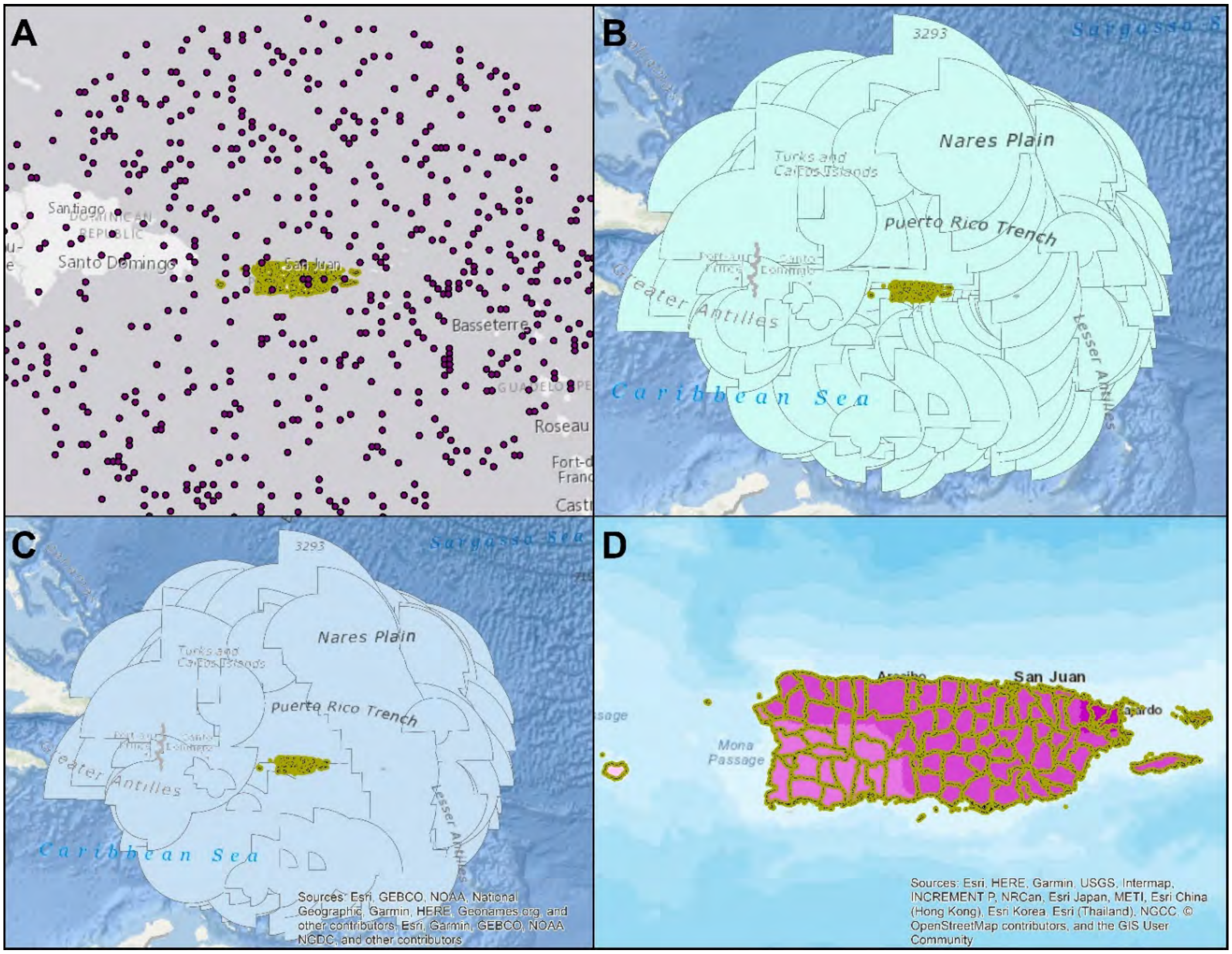

Figure 11: Hurricane Wind Hazard Frequency Analysis Process

Hazard Frequency Analysis Results

Eastern Puerto Rico has experienced more frequent hurricane wind speeds than the remainder of the Island, with the uninhabited Isla de Mona experiencing the least number (eight (8) instances) of hurricane force wind events. Fajardo and Luquillo municipalities are both completely within the highest category of hurricane frequency, nineteen (19) to twenty-one (21), with the Islands east of Fajardo seeing twenty-one (21) instances of hurricane winds during the last thirty (30) years. Most of the remainder of central and northwestern Puerto Rico has seen between sixteen (16) and eighteen (18) hurricane-force wind events during this same time frame; and southeastern portions of the main Island have been impacted thirteen (13) to fifteen (15) times (see map below).

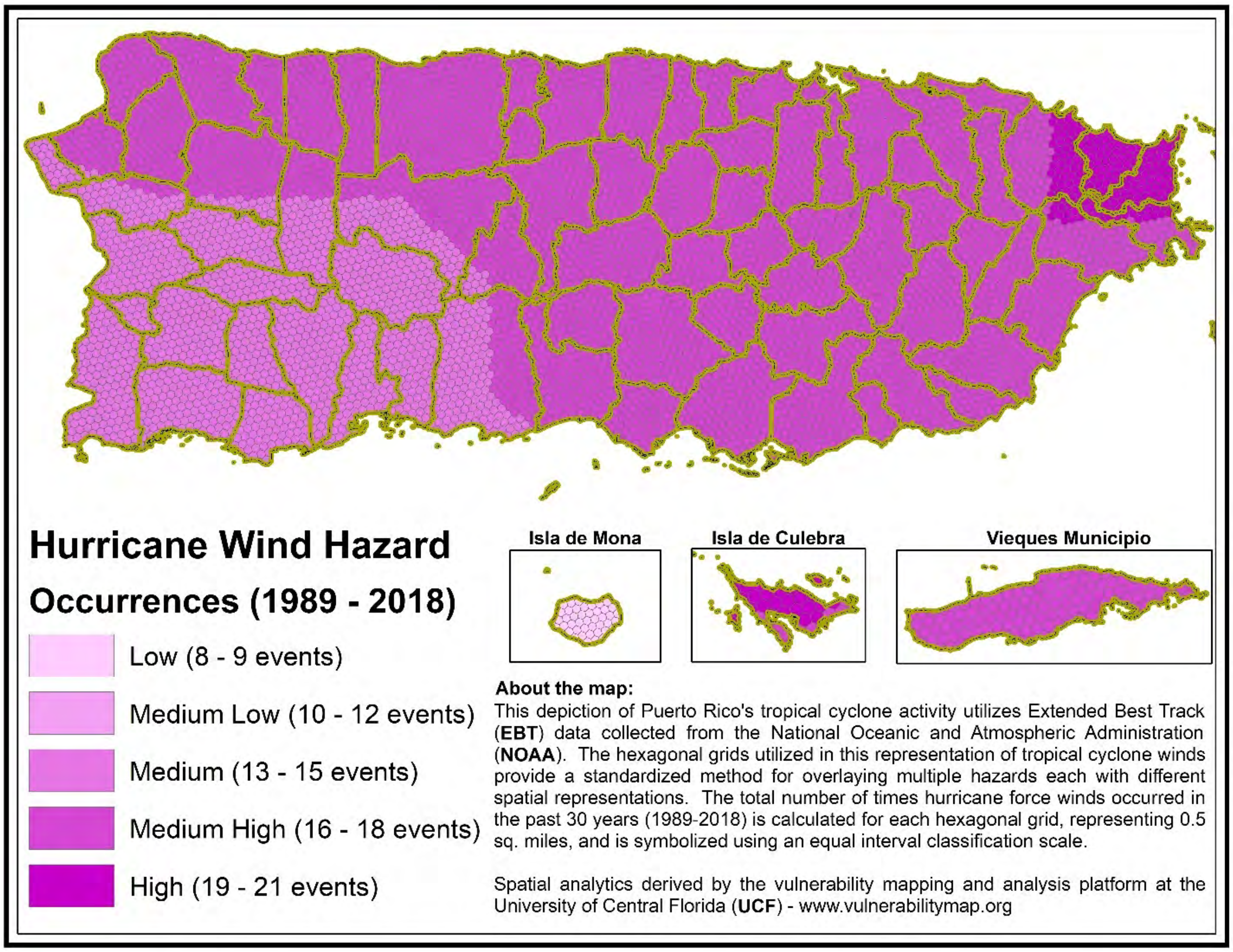

Figure 12: Hurricane Wind Hazard Areas

Rain Induced Landslides

Hazard Overview

According to the Puerto Rico's SHMP.[44], landslides occur when the force of gravity exerts its influence on crustal materials. The term landslide includes a wide variety of land movements, such as rockfalls, slope failures, and debris flow. This earth movement threatens life and property and can disrupt transit, dragging trees, houses, bridges and cars, among others.

Meteorological phenomena that cause intense and prolonged rainfall, such as tropical waves and tropical cyclones can trigger landslides. Population growth and/or migration and poor construction exacerbates the susceptibility of Puerto Rico to experience landslides.

Among the many factors causing the formation of landslides, the most important are soil type, slope or incline of the terrain, soil water saturation, erosion, the presence of depressions or cavities, human activities, and of course the occurrence of earthquakes. As stated in the Building Performance Assessment Team Report (**BPAT**) prepared after Hurricane Georges, "landslides will become a major problem in the future as more houses are built and there is more development in areas susceptible to these risks" (FEMA, March 1999).

As introduced in the 2016 SHMP, many of the landslides that occur in Puerto Rico are in a special category known as "debris flow". The flow occurs in mountainous areas with significant slopes during heavy rains. The rain saturates the soil and causes the ground level and peel strength loss, usually where the ground makes contact with the bedrock. There are many types of landslides, however, associated with soil saturation by water:

1. Slow landslides: slow and steady movement of soil or rock falls down the slope, often recognized by their content of tree trunks, twisted pieces of fences or retaining walls, tilted poles or fences.
2. Debris flow: fast-moving mass which combines loose soils, rocks, organic matter, air infiltration, and water to form a viscous flow that slides down the slope.
3. Debris avalanche: fast, or extremely fast, debris flow range.
4. Mud flow: the mass rapid flow of wet material containing at least fifty percent (50%) sand, silt and clay particles.

Data and Methods

The United States Geological Survey (**USGS**) completed a study of rainfall-induced landslides on Puerto Rico in early 2020.[45] The report summarizes creation of a new high-resolution model of rainfall-induced landslide susceptibility for the main Island. The main

[44] 2016 Puerto Rico Hazard Mitigation Plan. Accessed under file name "Puerto Rico Plan de Mitigación-Aprobado 02/08/2016" at the following website location: https://recovery.pr/en/document-library.
[45] United States. USGS. "Map Depicting Susceptibility to Landslides Triggered by Intense Rainfall, Puerto Rico". Accessed at https://pubs.er.usgs.gov/publication/ofr20201022. Accessed June 2020.

Island of Puerto Rico was classified at five (5) meter pixel scale into categories of Low, Moderate, High, Very High, or Extremely High susceptibility to land sliding during and soon after intense rainfall, such as is produced during tropical cyclones. Resulting raster GIS output data, downloaded as georeferenced files, were used in this assessment to understand sub-municipal-level landslide susceptibility. The output grid of susceptibility index (**SI**) values was summarized for each 0.5-square-mile hexagonal grid, and a focus on average landslide values was generated. Average SI values were used here because they provide suitable geospatial variability across Puerto Rico, whereas summarized maximum SI values skew the visualization towards a much less realistic landslide threat (see maps below).

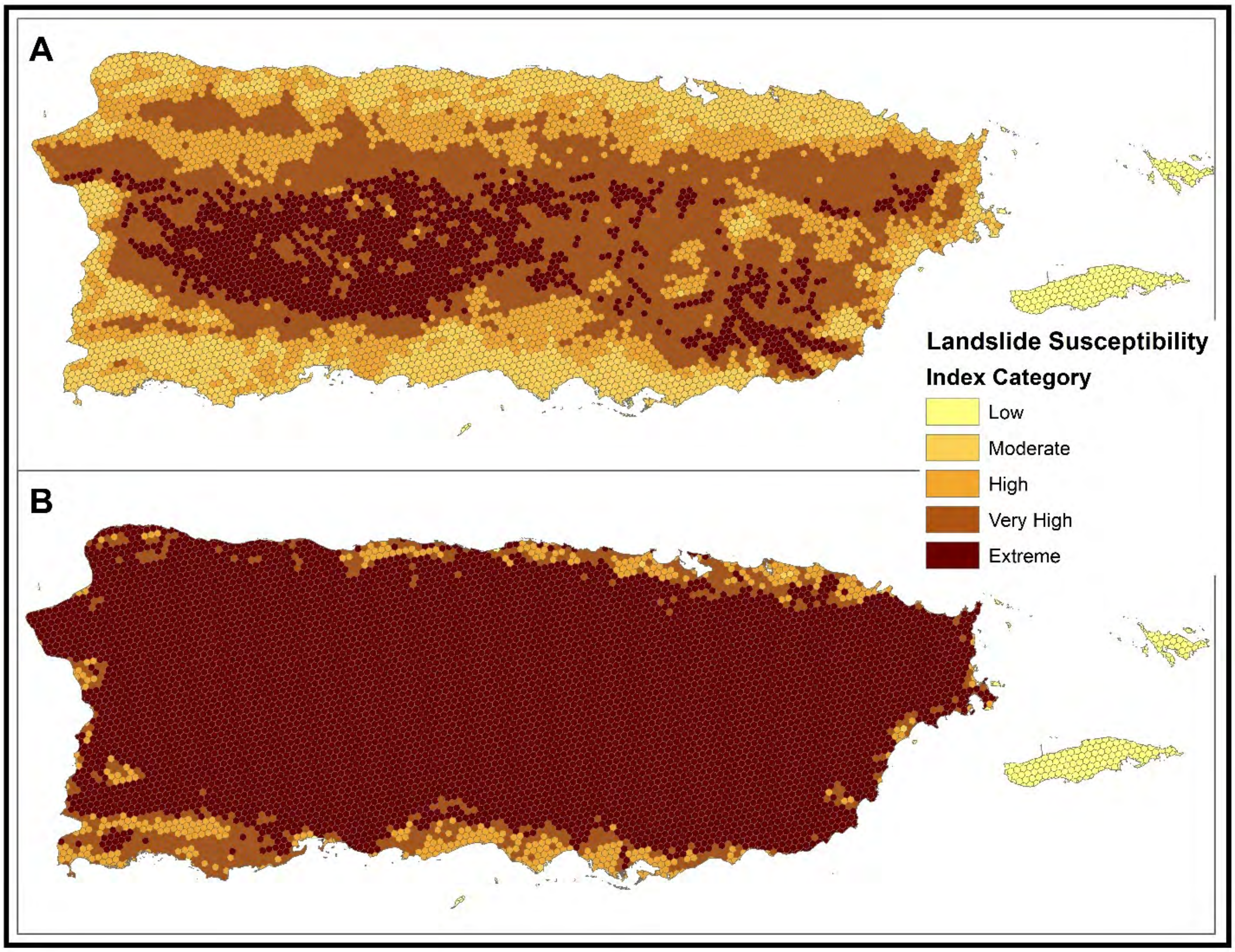

Figure 13: Rain Induced Landslide Susceptibility Index Average (A) vs Maximum (B) Score Comparison

Hazard Frequency Analysis Results

Unlike flooding and hurricane hazards where coastal areas are more highly threatened, landslide hazards are mainly a phenomena in hilly and mountainous areas. The map on the following page illustrates higher landslide susceptibility along the west central portion of the Island compared to the remainder of Puerto Rico. "Very high" landslide susceptibility trending from east to west coast and to the southeast indicates that landslide hazards are ever-present for many municipalities. In our analysis results, we see that places like Utuado (69 sq. mi.), Adjuntas (45.8 sq. mi.), and Ponce (40.6 sq. mi.) have the most land area in the "extreme" landslide category. Whereas other places have more than sixty percent (60%) of their total land area in the "extreme" SI category, like Maricao which has ninety-four percent (94%), Jayuya with seventy-five percent (75%), Adjuntas with sixty-eight percent (68%), and Las Marías with sixty-seven percent (67%).

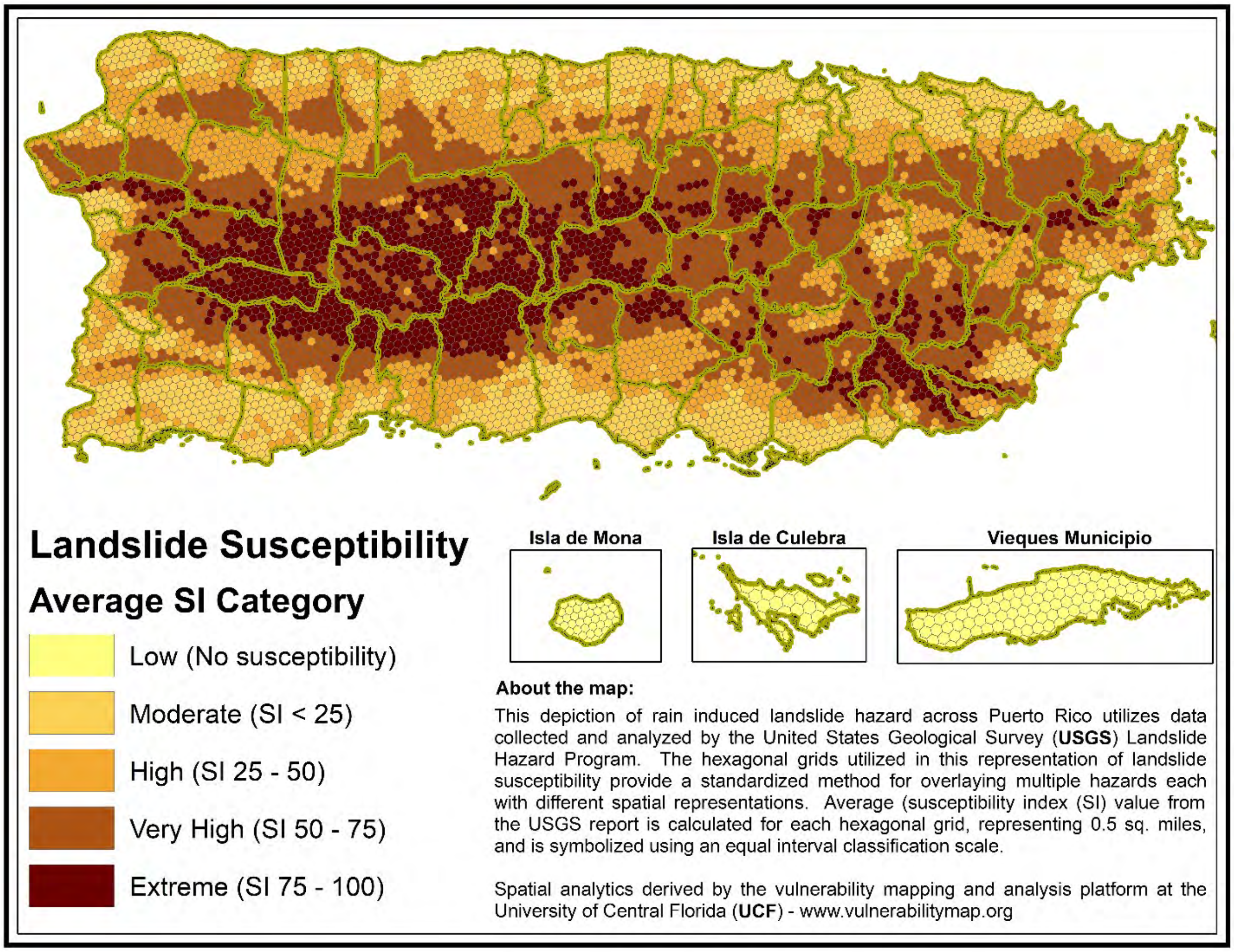

Figure 14: Rain Induced Landslide Susceptibility Areas

Severe Storms

Hazard Overview

Severe thunderstorms are defined by the National Weather Service as storms that have wind speeds of fifty-eight (58) miles per hour or higher, produce hail at least three-fourths (¾)-inch in diameter, or produce tornadoes. Thunderstorms simply require moisture to form clouds and rain, coupled with an unstable mass of warm air that can rise rapidly.

Thunderstorms affect relatively small areas when compared with hurricanes and winter storms, as the average storm is fifteen (15) miles in diameter and lasts an average of thirty

(30) minutes. Nearly 1,800 thunderstorms are occurring at any moment around the world. However, of the estimated 100,000 thunderstorms that occur each year in the US, only about ten percent (10%) are classified as severe. Thunderstorms are most likely to happen in the spring and summer months and during the afternoon and evening hours but can occur year-round and at all hours.

Despite their small size, all thunderstorms are dangerous and capable of threatening life and property in localized areas. Every thunderstorm produces lightning, which results from the buildup and discharge of electrical energy between positively and negatively charged areas. Each year across the US, lightning causes more deaths than tornados. It is responsible for an average of ninety-three (93) deaths, 300 injuries, and several hundred million dollars in damage to property and forests.

Thunderstorms can also produce large, damaging hail, which causes nearly $1 billion in damage to property and crops annually. Straight-line winds, which in extreme cases have the potential to exceed 100 miles per hour, are responsible for most thunderstorm wind damage. One type of straight-line wind, the downburst, can cause damage equivalent to a strong tornado and can be extremely dangerous to aviation. Thunderstorms are also capable of producing tornados and heavy rain that can lead to flash flooding.

Data and Methods

Severe storm warnings are issued by Puerto Rico's National Weather Service Forecast Office. Severe Thunderstorm Warnings will include where the storm is located, what towns will be affected by the severe thunderstorm, and the primary threat associated with the severe thunderstorm warning.[46] Severe storm warnings are collected and archived by Iowa State University's Environmental Mesonet.[47] Across Puerto Rico, there have been forty-four (44) severe storm warnings issued between 2002-2019 (see map on following page). Each hexagonal grid was appraised based on the number of watch boxes touching it over the time period of record. This summation was then divided by the number of years in the record to develop an average annual number of severe storms and mapped.

[46] United States. NOAA. "Severe Weather Definitions". Accessed at: https://www.weather.gov/bgm/severedefinitions
[47] Iowa State University. "Iowa Environmental Mesonet". Accessed at: https://mesonet.agron.iastate.edu/

Figure 15: Severe Storm Watch Boxes for Puerto Rico 2002-2019.

Hazard Frequency Analysis Results

The relatively low number of severe storm warnings across Puerto Rico, 3.6 per year, indicates that severe storms occur less often in relation to other portions of the US. However, severe storms can have dire consequences no matter how infrequently they occur. Western portions of the Island tend to have a higher number of severe storms than other portions; nearly seventy percent (70%) of San Sebastian's land area is in a high severe storm zone (see map on following page). Six (6) municipalities across Puerto Rico have some area in high hazard zones and another twenty-seven (27) have some area in medium high severe storm zones. Municipalities such as Añasco, and Las Marías have around twenty-five percent (25%) of their land area in high severe storm hazard zones.

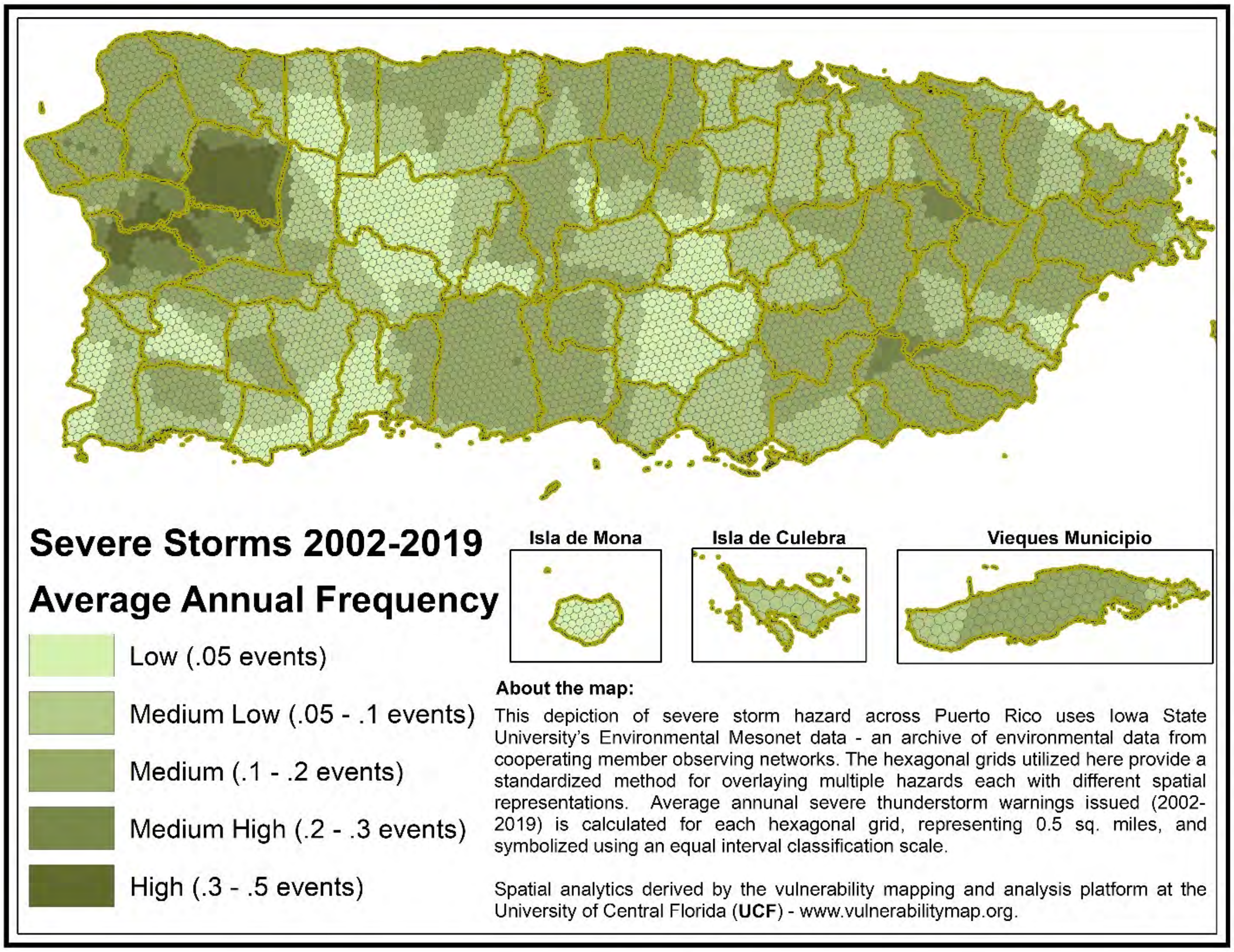

Figure 16: Severe Storm Hazard Frequency Areas

Hurricane Storm Surges

Hazard Overview

A storm surge is an elevated water level that is pushed towards the shore by the force of strong winds that result in the piling up of water. The advancing surge combines with the normal tides, which in extreme cases can increase the normal water height over twenty (20) feet. The storm surge arrives ahead of the storm's actual landfall, and the more intense the hurricane is, the sooner the surge arrives. Water rise can be very rapid and can move far inland, posing a serious threat to those who have not yet evacuated flood-prone areas. Debris carried by the waves can also contribute to the devastation. As the storm approaches the shore, the greatest storm surge will be to the north of the hurricane eye, in the right-front quadrant of the direction in which the hurricane is moving. Such a surge of high water topped by waves driven by hurricane force winds can be devastating to coastal regions, causing severe beach erosion and property damage along the immediate coast. Storm surge heights, and associated waves, are impacted by the shape of the continental shelf (narrow or wide) and the depth of the ocean bottom (bathymetry). A narrow shelf, or one that drops steeply from the shoreline and subsequently produces deep water close to the shoreline, tends to produce a lower surge, but higher and more powerful storm waves. While disassociated with the Saffir-Simpson Scale, storm surge remains the leading cause of mortality (or loss of life) of residents along the immediate coastal areas.[48]

Data and Methods

This assessment utilized Sea, Lake and Overland Surges from Hurricanes (**SLOSH**) datasets to map storm surge inundation for the conterminous US provided by National Oceanic and Atmospheric Administration (**NOAA**) National Storm Surge Hazard Maps.[49] SLOSH is a computerized model that estimates storm surge heights from tropical cyclones using pressure, size, forward speed, and track data to create a model of the wind field which pushes water. In each SLOSH basin or grid, tens of thousands of hypothetical tropical cyclones are simulated, and the potential storm surges are calculated. The model is best used for defining the potential flooding from storm surge for a location from a threatening hurricane, rather than as a predictor of the specific areas that will be inundated during a particular event. In island regions such as Puerto Rico, NOAA has coupled the SLOSH model and the Simulating Waves Nearshore (**SWAN**) third-generation wave model, developed at Delft University of Technology, to model storm surge and create Maximum of the Maximum Envelope of High Water (referred to as **MEOW** or **MOM**) products. For this assessment average Water MOM provides a worst-case snapshot for a particular storm category under "perfect" storm conditions.[50] Each MOM considers combinations of forward speed, trajectory, and initial tide level. These products are compiled when a SLOSH basin is developed or updated. It should be noted that no single hurricane will produce the regional flooding depicted in the MOMs. Instead, MOMs are intended to capture the worst-case high-water value at a particular location for hurricane evacuation planning. For this assessment, MOM water depth associated with each hurricane category was calculated for each hex-grid.

Hazard Frequency Analysis Results

Hurricane storm surges, a uniquely coastal phenomena, show differential hazardousness across Puerto Rico. Far eastern municipalities, including Culebra and Vieques Municipalities, as well as the eastern coast of the main Island, are categorized with deeper water depths from storm surge. The northeastern municipalities have more land area in storm surge zones for lower-category hurricanes, but deeper surge depth for more

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[48] Adapted from South Carolina Hazard Mitigation Plan. Accessed at: https://www.scemd.org/media/1391/sc-hazard-mitigation-plan-2018-update.pdf

[49] United States. NOAA. "National Storm Surge Hazard Maps – Version 2". Accessed at: https://www.nhc.noaa.gov/nationalsurge

[50] United States. NOAA. "Storm Surge Maximum of the Maximum (MOM)". Accessed at: https://www.nhc.noaa.gov/surge/momOverview.php

intense hurricanes (see maps in the following pages for category1, 2, 3, 4, and 5 storm surge).

Still, no coastline in Puerto Rico is immune from the possibility of hurricane storm surges. For each category storm, the SLOSH model indicates a differing amount of land area inundated to different depths in each municipality. As a result, the percentage of each municipality's land area changes for each SLOSH model run and category storm and the percent of each municipality's total island-wide land area also changes for different storms.

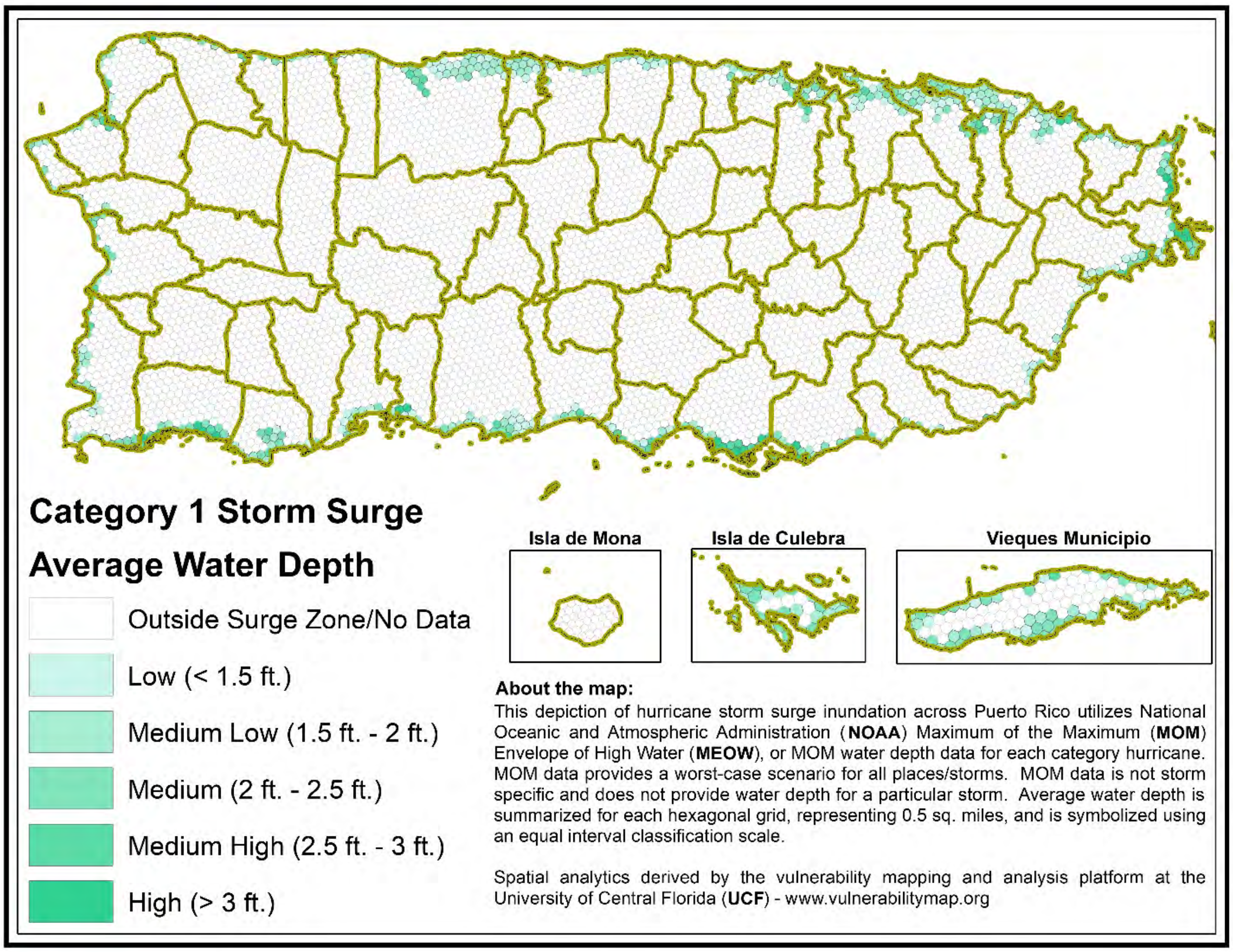

Figure 17: Hurricane Category 1 Storm Surge Hazard Areas

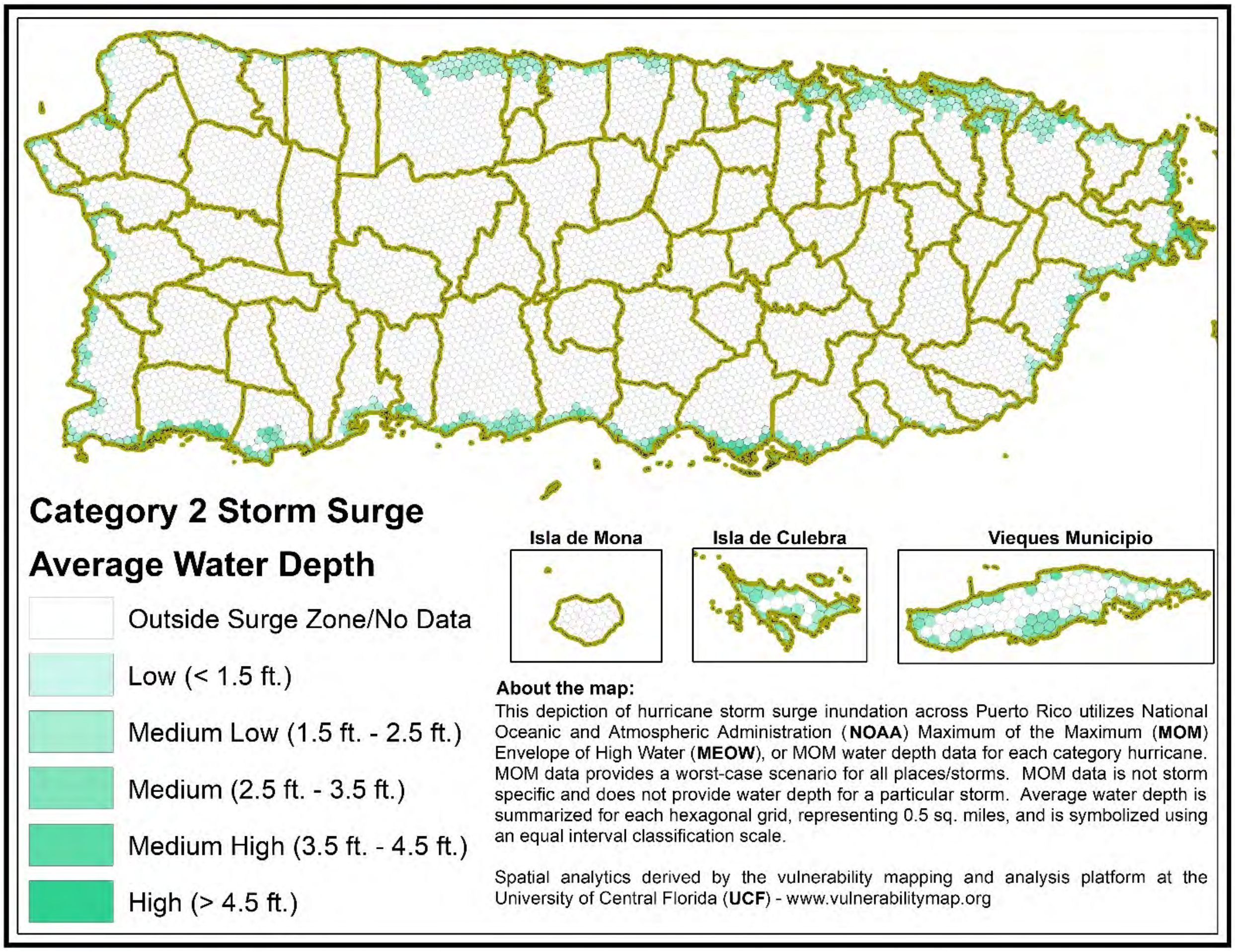

Figure 18: Hurricane Category 2 Storm Surge Hazard Areas

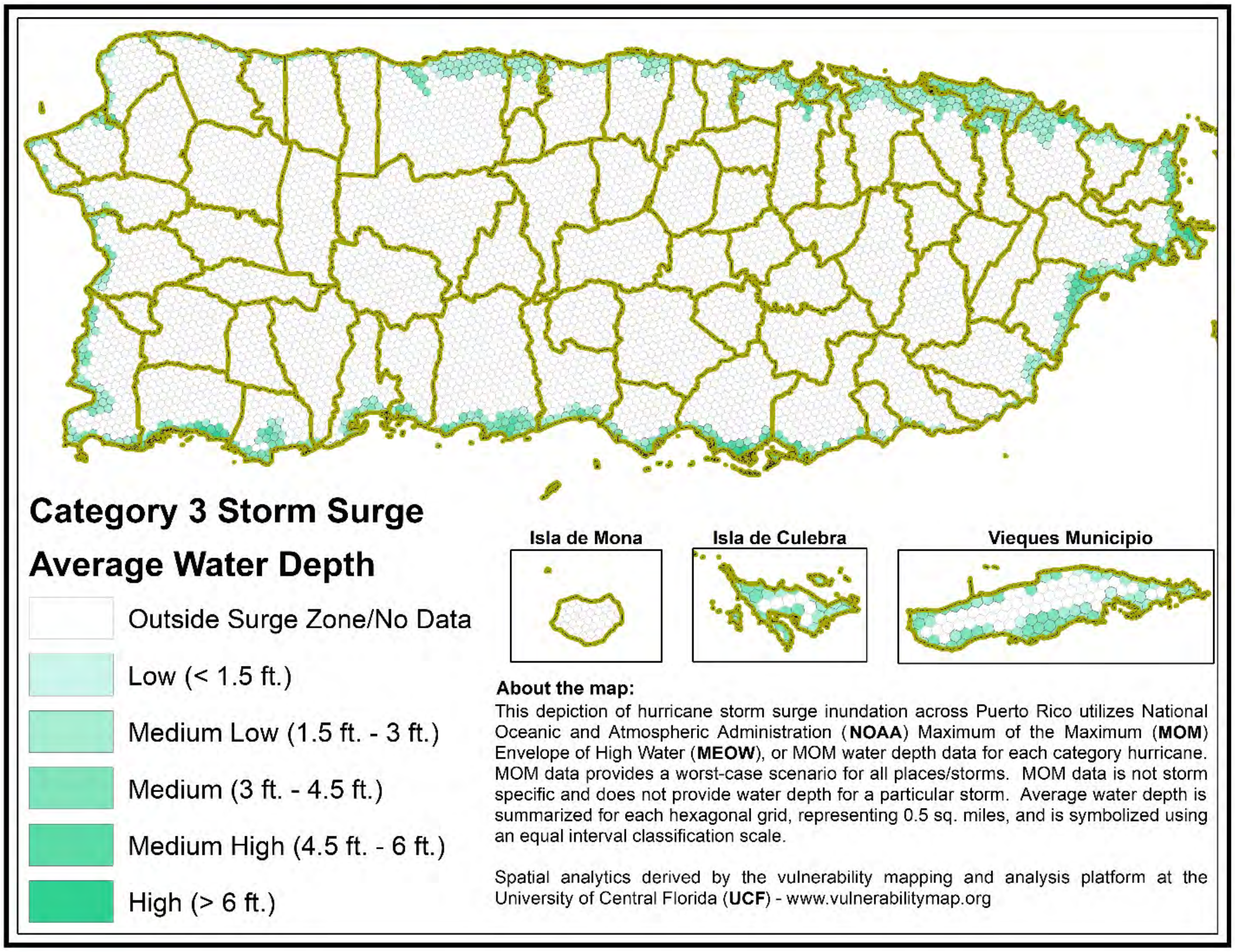

Figure 19: Hurricane Category 3 Storm Surge Hazard Areas

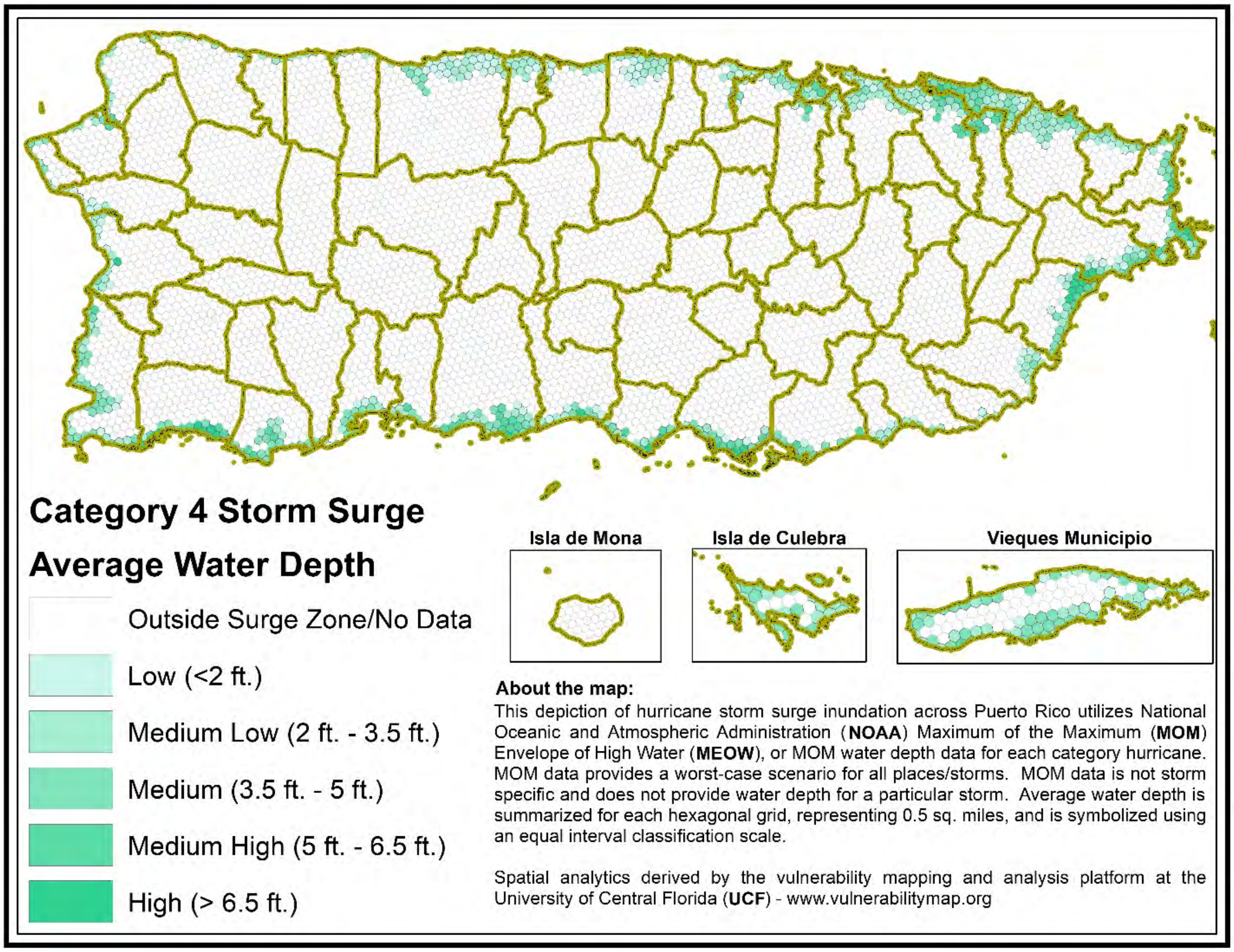

Figure 20: Hurricane Category 4 Storm Surge Hazard Areas

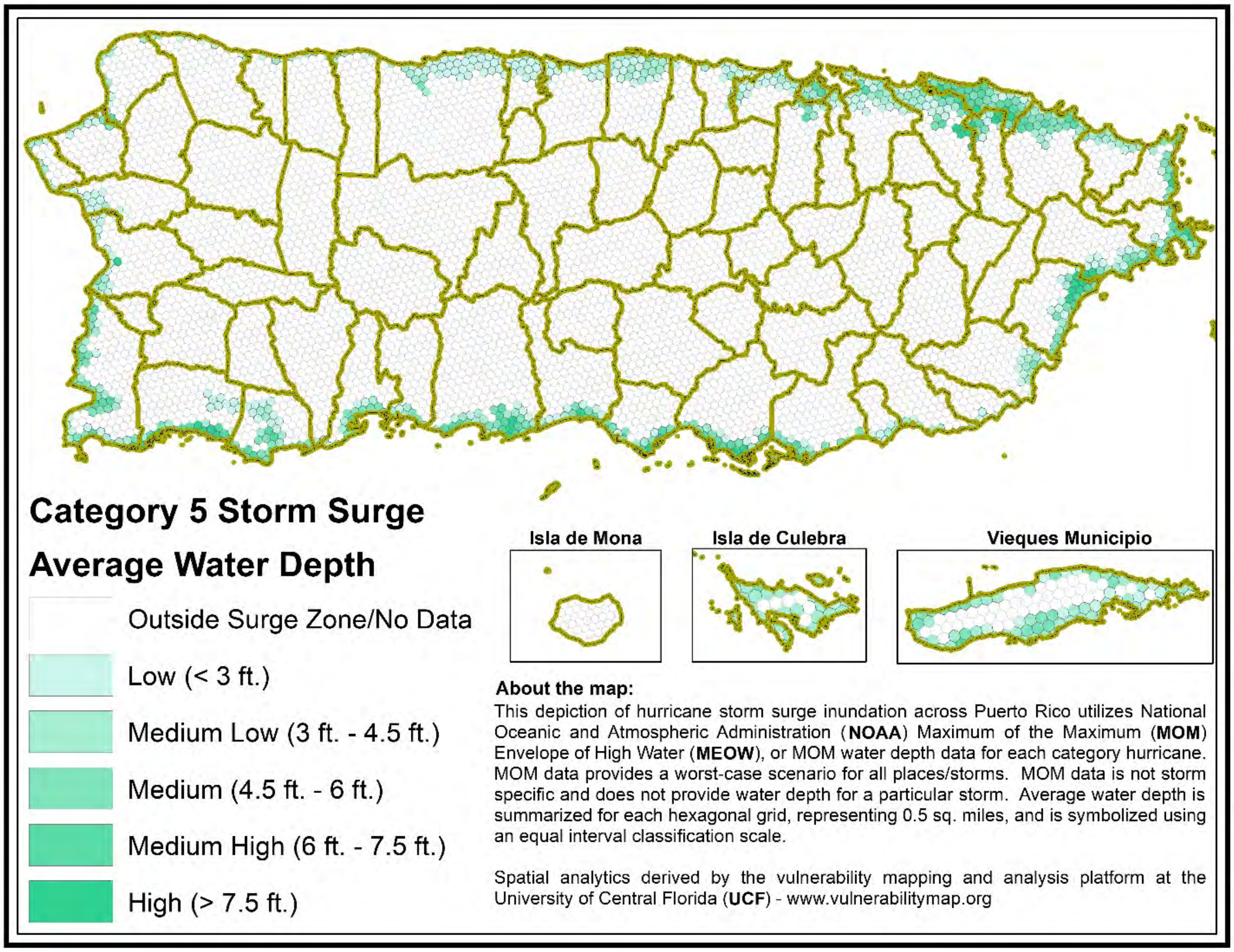

Figure 21: Hurricane Category 5 Storm Surge Hazard Areas

Earthquakes

Hazard Overview

As with most of the Caribbean, Puerto Rico is subject to significant threat from earthquakes. Earthquakes represent a particularly severe threat due to irregular time intervals between these events, lack of adequate forecasts, and the catastrophic damage that can occur as a result of a significant event of this nature.

An earthquake is caused by the release of stored energy within, or along the edge of, the tectonic plates of the Earth. They are characterized by a sudden shaking of the earth. The severity of an earthquake depends on its place of origin (epicenter) and the amount of energy released. Upon the occurrence of the earthquake, seismic waves radiate from the earthquake source, causing the shaking of the earth. The severity of the tremor increases as energy is released and decreases according to its distance from the epicenter. The tremors can be felt hundreds of miles from its epicenter. The intensity of shaking is the result of several factors, such as: the extent and type of earthquake, the distance from the epicenter, the area's soil conditions, and the relative orientation of the site with respect to the seismic event.

Among the damage earthquakes can cause are liquefaction, landslides, and significant damage to buildings and infrastructure. Liquefaction is a phenomenon that causes unconsolidated soils to lose their strength and act similar to a viscous fluid (like quicksand) when these soils are subject to tremors due to an earthquake. The frequency and intensity of liquefaction that can occur during an earthquake is impacted by several factors including: the geological conditions of the area, groundwater depth, the tremor severity, and magnitude of the earthquake.

Earthquakes can cause landslides and other types of soil failures. Landslides are sudden movements of materials that emerge from the hills or mountains, free fall, sliding or rolling down. Landslides caused by earthquakes can occur on natural slopes, cut slopes on the ground, eroded rocks, or filled slopes. They are common in areas where they are abruptly cut off the slopes, on plain soils or fractured eroded rock. The frequency and intensity of landslides that may occur during an earthquake are due to several factors, including: geological materials contained in the area, the steepness of the slope, the water content of the material that slides, trembling land, and the magnitude of the earthquake.

Data and Methods

The USGS, charged with overseeing all geophysical hazard activity in the US and its protectorates, has completed several studies of earthquake risk for Puerto Rico. One of the most recent is a 2003 study of US Seismic Hazard Maps – Puerto Rico and the US Virgin Islands, Samoa and the Pacific Islands, and Guam and the Northern Mariana Islands.[51] This study provides gridded seismic hazard curve data, gridded ground motion data, and mapped gridded ground motion values for the Puerto Rico region. In this case, as in many probabilistic seismic hazard analysis (**PHSA**), the greater than two percent (2%) probability of peak ground acceleration (**PGA**) has become the de facto measure for estimating seismic activity. Although considerable discussion in seismology, engineering, and emergency management is beginning to shift away from PHSA and PGA as a measure of risk[52, 53] (e.g., hazard X vulnerability) it still proves to be useful for understanding the occurrence frequency of ground shaking. For the purposes of this hazard assessment, the greater than two percent (>2%) exceedance of Peak Ground Acceleration provides a

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[51] United States. USGS. "U.S. Seismic Hazard Maps – Puerto Rico and the U.S. Virgin Islands, Samoa and the Pacific Islands, and Guam and Northern Mariana Islands". Accessed at: https://www.usgs.gov/natural-hazards/earthquake-hazards/science/us-seismic-hazard-maps-puerto-rico-and-us-virgin-islands?qt-science_center_objects=0#qt-science_center_objects

[52] Wang, Z. "."Understanding Seismic Hazard and Risk A Gap Between Engineers and Seismologists". Accessed at: https://www.iitk.ac.in/nicee/wcee/article/14_S27-001.PDF

[53] Mulargia, Francesco, Stark, Philip B., Geller, Robert J., "Why is Probabilistic Seismic Hazard Analysis (PHSA) still used?" *Physics of the Earth and Planetary Interiors*, Volume 264, March 2017, Pages 63-75. Accessed at: https://www.sciencedirect.com/science/article/pii/S0031920116303016

useful tool for understanding where the hazard is likely to occur, but not which buildings or communities are likely to be adversely impacted. In this assessment, average PGA values were calculated for each hexagonal grid and mapped using standard deviations showing us a clear pattern of increased hazard across Puerto Rico.

Hazard Frequency Analysis Results

The map below shows that earthquake threat generally decreases from southwest to northeast across Puerto Rico. Four (4) municipalities, Cabo Rojo, Lajas, Guánica, and Yauco have greater than ten (10) sq. miles of land area in the highest PGA zones, and thirty-six (36) municipalities have greater than ten (10) sq. miles in the second highest hazard category. Thirty-three (33) municipalities have one hundred percent (100%) of their land area in a high or medium-high earthquake hazard zone, as defined by PGA, of forty (40) or greater.

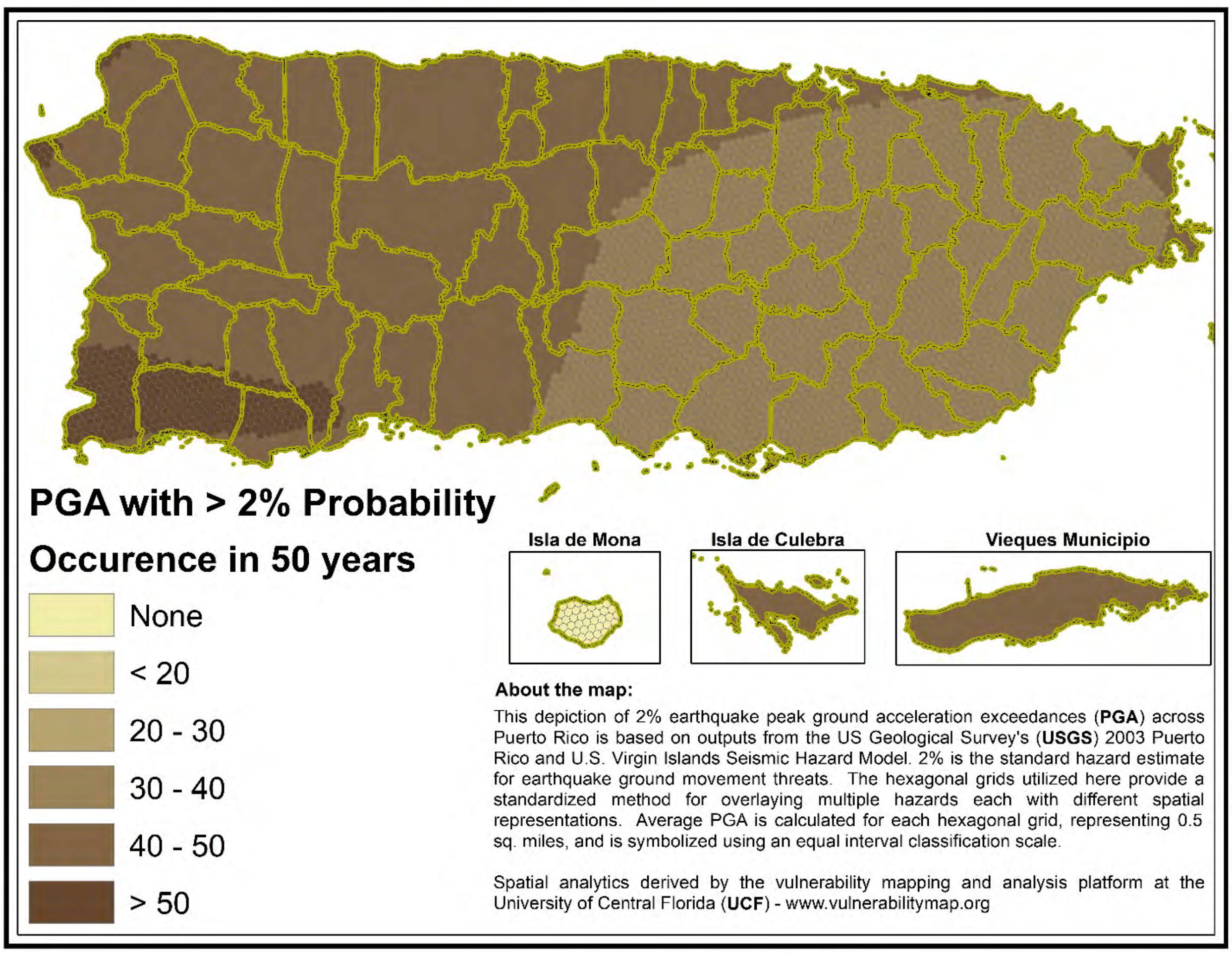

Figure 22: Earthquake Hazard Areas

Tsunami

Hazard Overview

A tsunami is a series of waves caused generally by a vertical displacement on the bottom (bed) of the sea caused by an earthquake under the seabed. Tsunamis can also be caused by underwater landslides or volcanic eruptions. Tsunami characteristics are different in deep and surface water events. In deep water, waves travel at speeds up to 500 miles per hour (mph), but the visual indication of a deepwater tsunami is typically a low wave--under one foot in height. However, as these deepwater waves approach coastal areas they greatly decrease in speed and dramatically increase in height. Nearshore tsunami waves, sometimes reach heights of more than ninety-eight (98) feet, can cause great cost to lives, property, and livelihoods when they impact the coast.[54]

Data and Methods

Puerto Rico's Seismic Network (**PRSN**), part of the Department of Geology of the University of Puerto Rico in Mayagüez, has a mission to detect, process, and investigate the seismic activity in the region of Puerto Rico to aid in public security, education, engineering, and scientific research. In 2012, PRSN completed a tsunami inundation model considering an 8.5 magnitude catastrophic event on the north of Puerto Rico.[55] The results of this model include geospatial data files displaying flood inundation areas across Puerto Rico. Like flood hazard, these polygonal representations of tsunami hazard were spatially intersected with Puerto Rico's 0.5-square-mile hexagonal grid to produce a spatial representation of tsunami inundation hazard across Puerto Rico.

Hazard Frequency Analysis Results

Tsunamis are mainly a coastal hazard, yet potential impacts are uneven across the coastline (see map on the following page). Municipalities on the north shore of Puerto Rico appear to have more land area in tsunami hazard zones in comparison to other parts of the Island. These results are dependent on many factors, but could be related to the fact that the 2012 model was based on an event in the north of Puerto Rico. Additionally, municipalities along Puerto Rico's western shore have land areas in high tsunami hazard zones. Thirty-seven (37) municipalities have land in high tsunami impact areas with Loíza topping the list in terms of total land area in the high tsunami hazard zone.

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[54] 2016 Puerto Rico Hazard Mitigation Plan. Accessed under file name "Puerto Rico Plan de Mitigación-Aprobado 02/08/2016" at the following website location: https://recovery.pr/en/document-library.

[55] Puerto Rico Seismic Network. "Tsunami Ready ®". Accessed at: http://redsismica.uprm.edu/English/tsunami/tsunamiprogram/prc/gisdataenglish.php

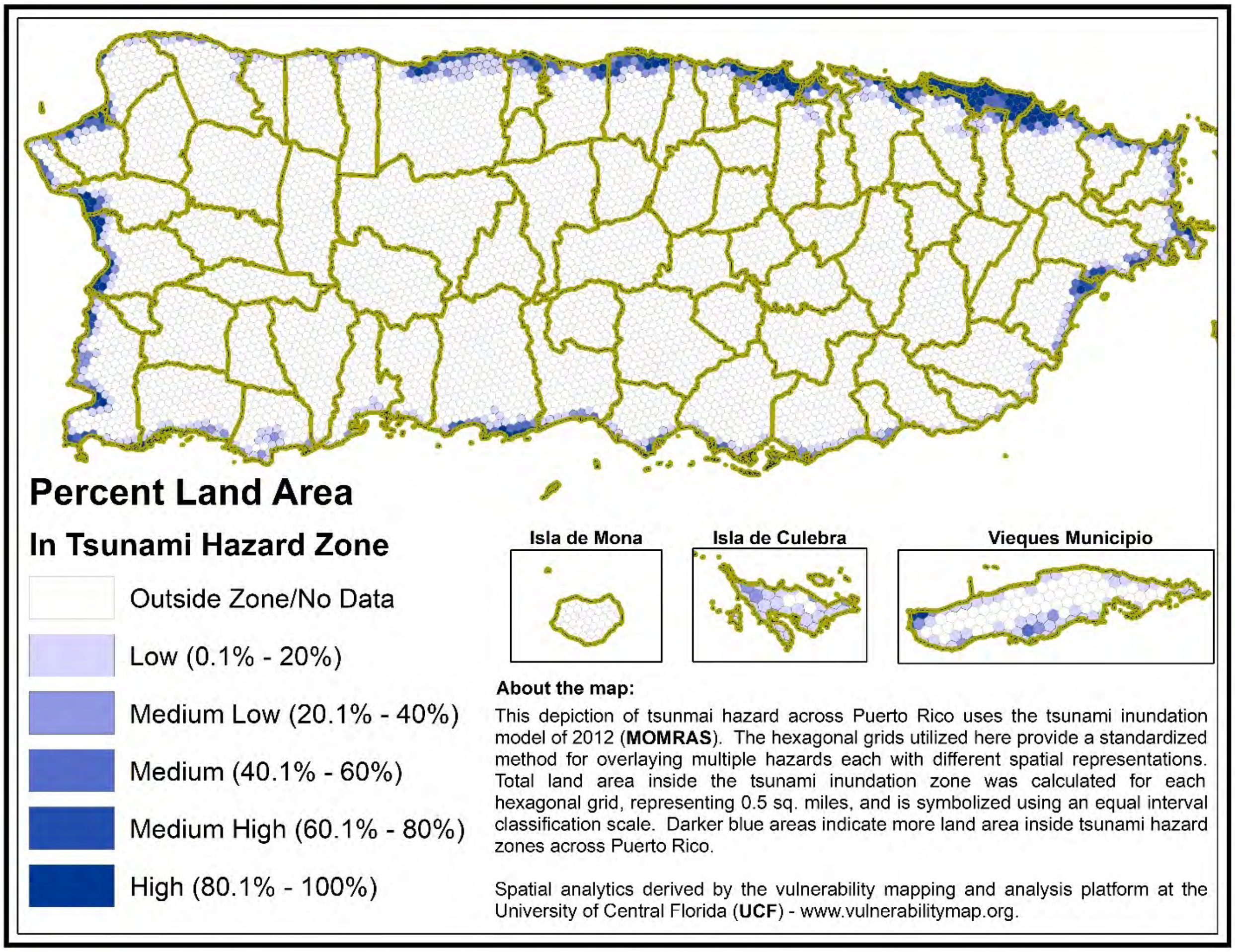

Figure 23: Tsunami Hazard Areas

Drought

Hazard Overview

Drought is described as "long periods of abnormal weather enough for water shortages to cause serious hydrological imbalances in the affected area". In simpler terms, a drought is a period of unusually dry weather that persists long enough to cause serious problems, such as damage to agriculture and rationing in the provision of potable water to the population. The severity of a drought depends on the degree of impairment in humidity levels, duration, and size of the affected area.

There are four (4) main approaches that can define a drought.

1. Meteorological Focus: a measure of deviation from normal precipitation levels. Due to climatic differences, which can be considered a drought in one (1) country may not necessarily be a drought elsewhere.
2. Agricultural Focus: refers to the situation where the amount of moisture in the soil does not meet the needs of a particular crop.

3. Hydrological Focus: occurs when surface water sources and groundwater are below normal.
4. Socioeconomic Focus: refers to the situation that occurs when physical shortages in water supplies begin to affect people.

The main cause of any drought is the lack of rain or precipitation. This phenomenon is called meteorological drought, and if it lasts it leads to a hydrological drought characterized by a disparity between the natural availability of water and natural water demands. In extreme cases you can get to drought. The lack of precipitation for an extended period of time can have disastrous consequences for agriculture and metropolitan areas. In some areas of the countryside, it does not take long, as several weeks without rain can cause damage to crops. These areas must take measures on consumption savings, such as rationing.

Data and Methods

Produced jointly by the National Drought Mitigation Center (**NDMC**) at the University of Nebraska-Lincoln, NOAA, and the US Department of Agriculture (**USDA**), the United States Drought Monitor (**USDM**) provides geospatial representations of drought hazard areas for the entire US and outlying areas. The NDMC hosts the web site of the drought monitor and the associated data, and provides the map and data to NOAA, USDA and other agencies.[56] Polygons produced by the USDM represent areas that have had drought conditions from 2000-2019 across Puerto Rico. Each hexagonal grid was populated with the number of instances (weeks) of drought and categorized using an equal interval classification.

Hazard Frequency Analysis Results

Drought hazard is most prevalent in the south central and central Island areas and radiates out along the southern coast and into the central and north central portions of the Island (see map on the following page). Salinas municipality, (with fifty-eight (58) square miles) has eighty-three percent (83%) of its land area in the highest drought frequency category and more than sixty-three percent (63%) of all the high drought areas across the Island are also located in the area. Several surrounding municipalities have a majority (if not all) of their individual land area in the medium-high drought category and when ranking each municipality across all hazard categories by area, one can easily see the most threatened areas in terms of drought.

[56] The National Drought Mitigation Center, University of Nebraska-Lincoln. "United States Drought Monitor". *Map Released: August 13,2020, 2020*. Accessed at: https://droughtmonitor.unl.edu/

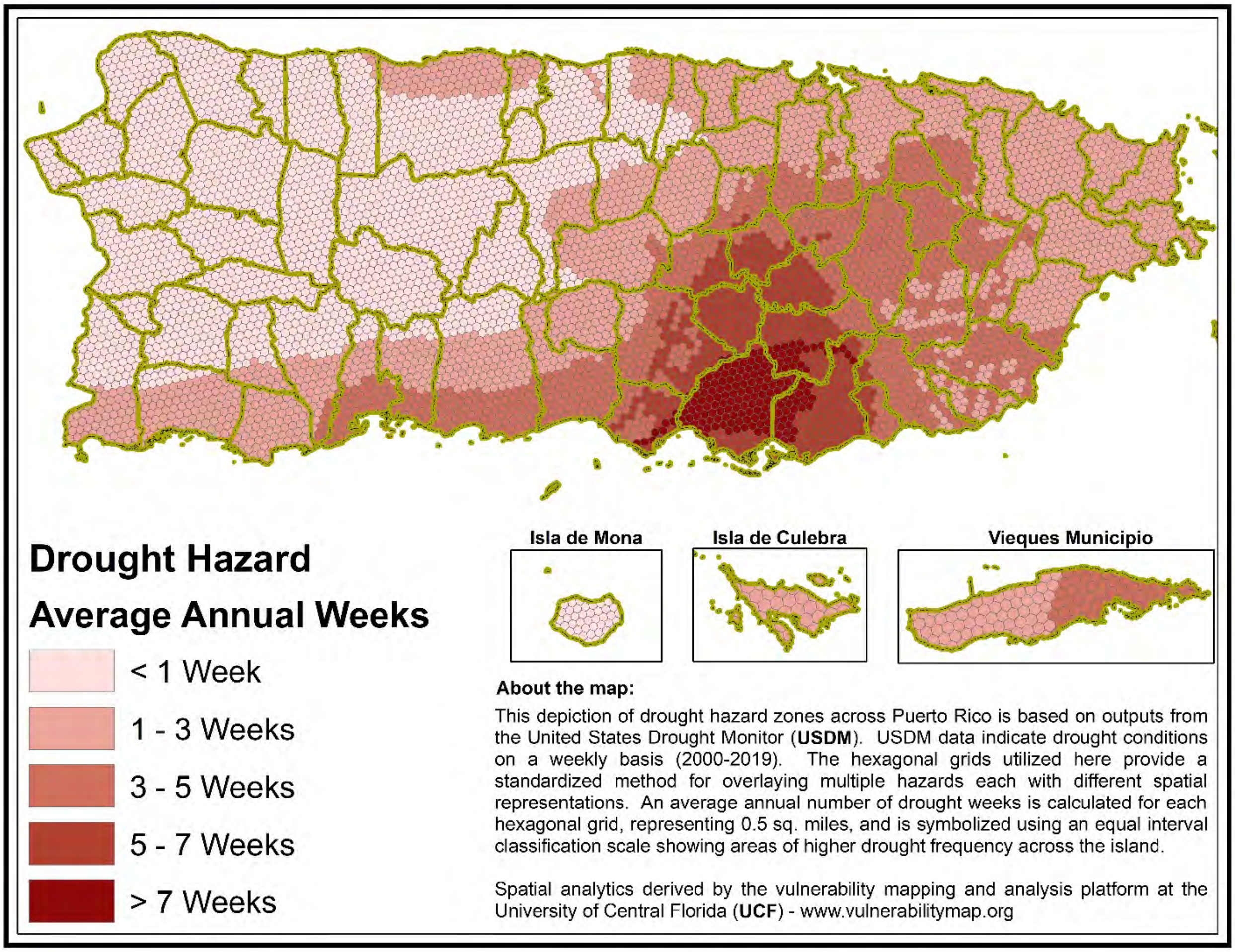

Figure 24: Drought Hazard Areas

Wind

Hazard Overview

Wind is "the horizontal motion of the air past a given point".[57] Winds occur when there are differences in air pressure, always moving from a location with high pressure to one with relatively lower pressure. Wind speed depends on two factors: (a) the pressure difference between two areas, and (b) the distance between those two areas. Stronger winds occur because of higher pressure difference and/or closer areas of high/low pressure. Wind speed is usually expressed in miles per hour or knots. The direction from which the wind is blowing is used to describe the wind. For example, "westerly winds" mean winds are blowing from the west. The wind events discussed in this assessment are non-hurricane, and non-tornadic wind events (i.e., mostly thunderstorm winds). Very few wind advisory events, sustained winds of thirty to thirty-nine (30-39) mph or wind gusts of forty-six to fifty-seven (46-57) mph occur in Puerto Rico on an annual basis.

[57] United States. NOAA. "National Weather Service Glossary". Accessed at: National Weather Service, Glossary, http://w1.weather.gov/glossary/

Data and Methods

Puerto Rico has only a limited number of weather stations on the Island capable of collecting crucial hourly information about temperature, fog, wind, and other atmospheric conditions. Using insufficient data coverage to determine wind hazard zones could result in both under and over-estimation of hazard areas. Because Puerto Rico's wind sensor array is less than optimal, this assessment used hourly ten (10)-meter u- and v- wind component data (units: m/s) (1989-2018) obtained from ERA5 (ECMWF Atmospheric Reanalysis, the fifth generation) data. This is a satellite-derived dataset of wind speeds. The spatial resolution of this dataset is 0.25-degree latitude-longitude. The hourly windspeed at ten (10)-meter is calculated from u- and v- wind components. As for each hexagon, the daily max hourly wind speed is determined first, then the average annual number of days that daily max hourly wind speed exceeds thirty (30)-knot is calculated.

Hazard Frequency Analysis Results

Wind hazard is a lower threat to lives, livelihoods, and infrastructure across Puerto Rico than other hazards. Most non-hurricane related wind events do not reach the threshold to cause damage, however the frequency of thirty (30)-knot winds across the Island merits review. The map on the following page shows average annual frequency of thirty (30)-knot wind events over the thirty (30)-year period from 1989-2018 and indicates that areas on the western and eastern portions of the Island have slightly greater frequency than the remainder of the Island. Vieques, Culebra, and Ceiba all have land in high wind hazard zones. Cabo Rojo and Rio Grande, Aguadilla, and Isla de Mona all have significant land area in the medium high hazard zone.

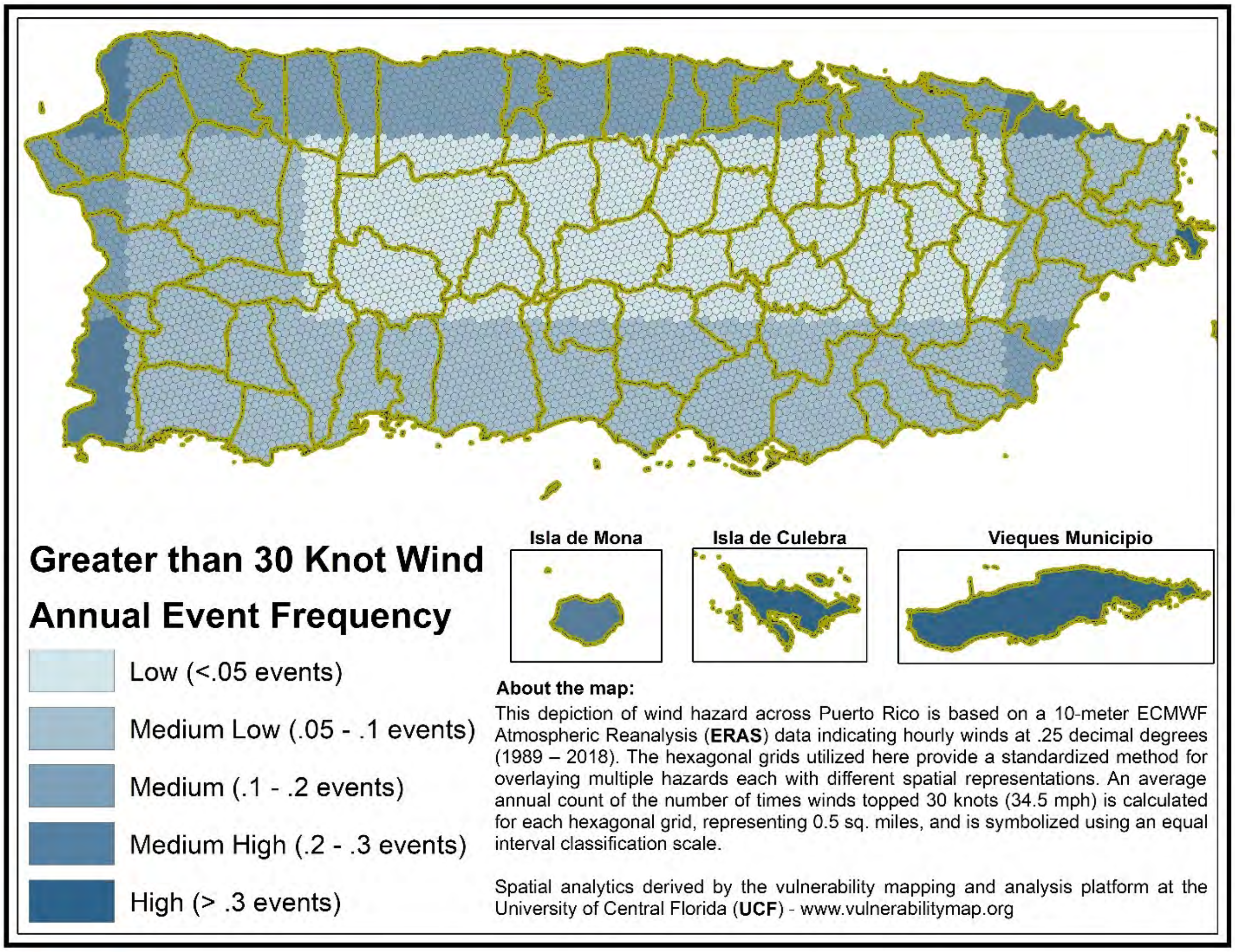

Figure 25: Wind Hazard Areas

Fog

Hazard Overview

Fog is a hazard to drivers, mariners, and aviators. Since 2003, three (3) fatal plane crashes have been connected to fog events on Puerto Rico.[58] There are several different conditions under which fog forms. Across Puerto Rico, radiation fog is the most common type of fog. Radiation fog mostly forms in the early morning and dissipates rapidly as air near to the ground cools. When the air reaches saturation, fog will form. Initially, fog will form near, or at, the surface and will thicken as the air continues to cool (e.g., overnight) and also extend upward. Radiation fog mostly occurs in sheltered valleys and near bodies of water. Its appearance is usually patchy and localized since wind disrupts the development of radiation fog.[59]

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[58] National Transportation Safety Board. Data Repository Accessed at: https://www.ntsb.gov/_layouts/ntsb.aviation/Results.aspx?queryId=cd2e02e2-52f4-43a4-8809-b5a2462b96a1

[59] Calvesbert, Robert J. Climate of Puerto Rico and U.S. Virgin Islands. U.S. Department of Commerce, "Climates of the States". Accessed at: https://play.google.com/books/reader?id=n6MJAQAAIAAJ&hl=en&pg=GBS.PA1

Data and Methods

Global Historical Climatology Network (**GHCN**) data for the Island provided adequate information on fog hazard occurrence across eleven (11) weather stations collecting this information between 1989-2018 (see map below). An island-wide depiction of daily fog frequency of occurrence was interpolated from these weather stations and summarized to the 0.5-square-mile hexagonal grid to provide a more nuanced understanding of fog hazard frequency across Puerto Rico.

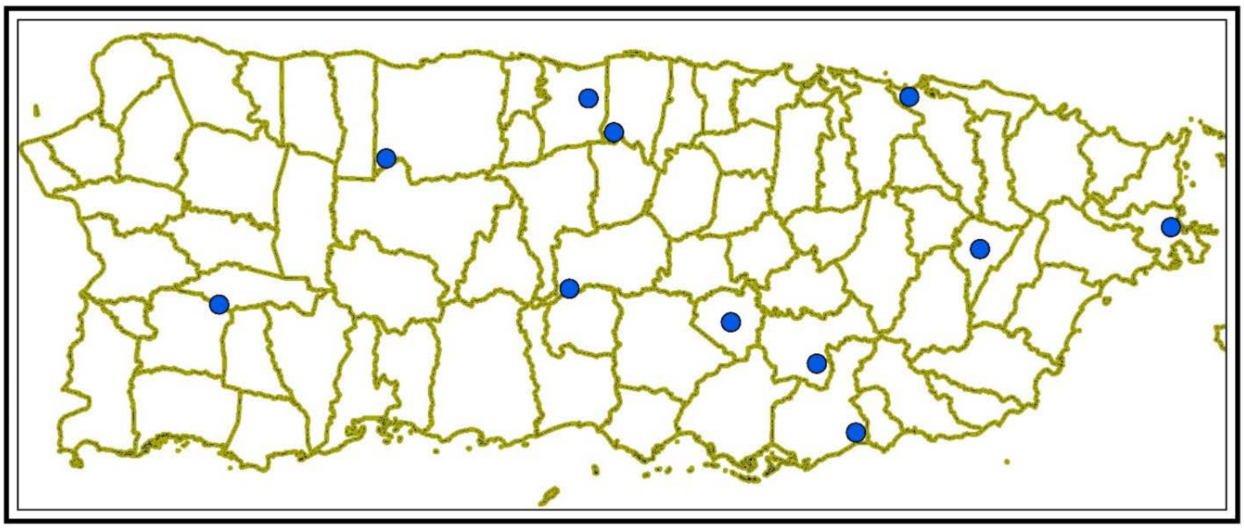

Figure 26: Weather Stations Collecting Daily Fog Hazard Information

Hazard Frequency Analysis Results

Fog hazard is most frequent in eastern and northern portions of Puerto Rico with San Juan and surrounding municipalities experiencing the highest average annual fog hazard occurrence. (See map on following page). Although fog is not a frequent hazard and does not cause significant damage to property and lives, the spatial distribution of fog hazards affecting some places more than others should be noted.

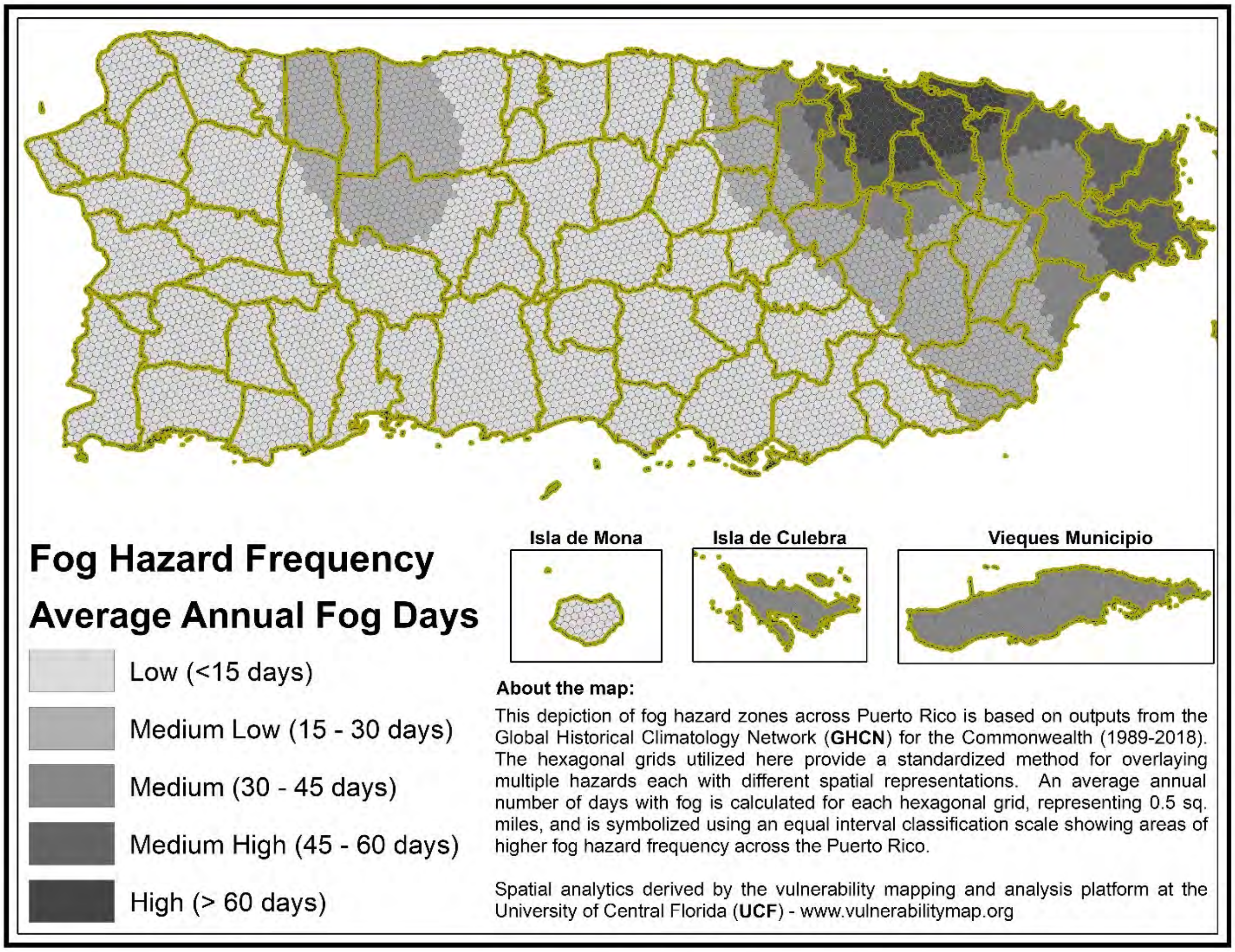

Figure 27: Fog Hazard Areas

Hail

Hazard Overview

An infrequent hazard in Puerto Rico, hail can occur year-round during severe thunderstorms. Hail is a precipitation type, consisting of ice pellets that form when water droplets bounce above and below the freezing level of the atmosphere. The size of hail is a function of the intensity of the updraft, and hence the severity of the storm. Strong vertical motion can keep lifting hailstones so that they continue to accumulate in size. The speed when hail reaches the ground, or its terminal velocity, is a function of its size and weight. Hail can be small, generally pea-sized. But it may be larger, capable of damaging property and killing livestock and people.

Data and Methods

The hail climatology data (1996-2018) are obtained from the Severe Weather Database, NOAA Storm Prediction Center. Although the records of the entire dataset start from 1955, the earliest records in Puerto Rico start in 1996. Start and end locations for each hail event provide a general area of impact across the Island. For each hexagon, the total frequency is calculated as the number of hail events intercepting each hexagon. Annual frequency is calculated by dividing the total frequency by the number of years on record.

Hazard Frequency Analysis Results

Hail hazards occur rarely across Puerto Rico. Since 1996 only thirty-two (32) instances of hail in Puerto Rico have been recorded by NOAA. However, a general pattern of hail events indicates that this hazard has impacted central portions of the Island more than coastal areas (see map below). Generally, most municipalities have few hail events, leaving most areas of the Island in lower hazard zones and most municipalities with generally low amounts of land in high hail hazard zones.

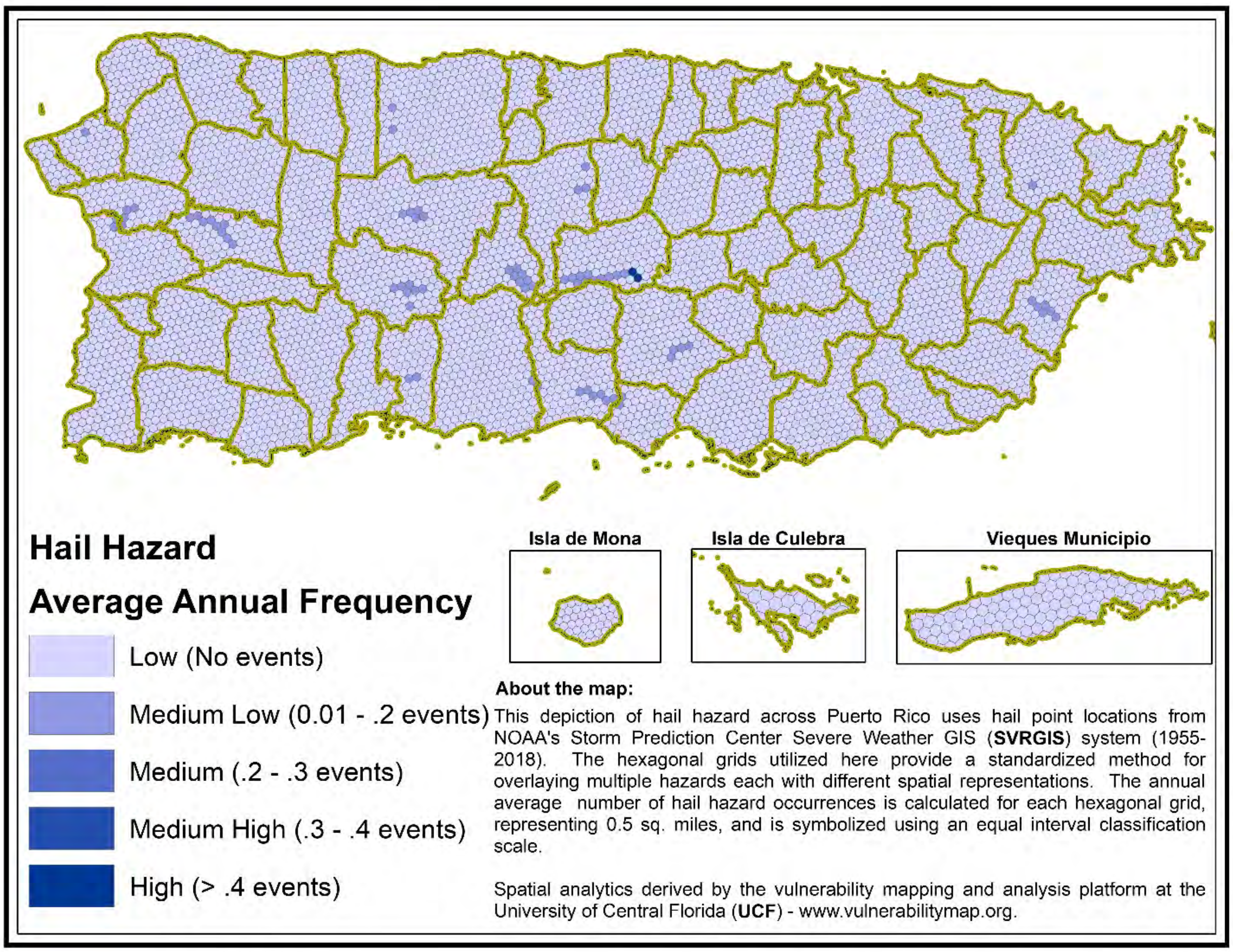

Figure 28: Hail Hazard Areas

High Temperatures

Hazard Overview

A heatwave is an extended period of above-normal temperatures over a given period of time. The World Meteorological Organization (**WMO**) recommends the declaration of a heatwave when the daily maximum temperatures exceed the average maximum temperatures by nine degrees Fahrenheit (9°F) and last for a period of at least five (5) days. Temperature alone is insufficient to describe the stress placed on humans, as well as flora and fauna, in hot weather. It is crucial to consider the effect of relative humidity since it is essential to the body's ability to perspire and cool off. Once air temperature reaches thirty-five degrees Celsius (35°C)/ninety-five degrees Fahrenheit (95°F), perspiration becomes the most important manner of heat loss. Perspiration does not work if the water cannot evaporate (i.e. sweating in high relative humidity is less effective than in dry climate).

Data and Methods

A similar method to that of fog was used for high-temperature data. Here, fourteen (14) stations have collected historical temperature data across the Island. Linking these stations to GHCN data for the Island provided information on temperature across fourteen (14) weather stations that were collecting this information between 1989-2018 (see map below). An island-wide depiction of the daily frequency of temperatures greater than ninety-five degrees Fahrenheit (95°) was interpolated from these weather stations and summarized to the 0.5-square-mile hexagonal grid to provide a more nuanced understanding of heat hazard frequency across Puerto Rico.

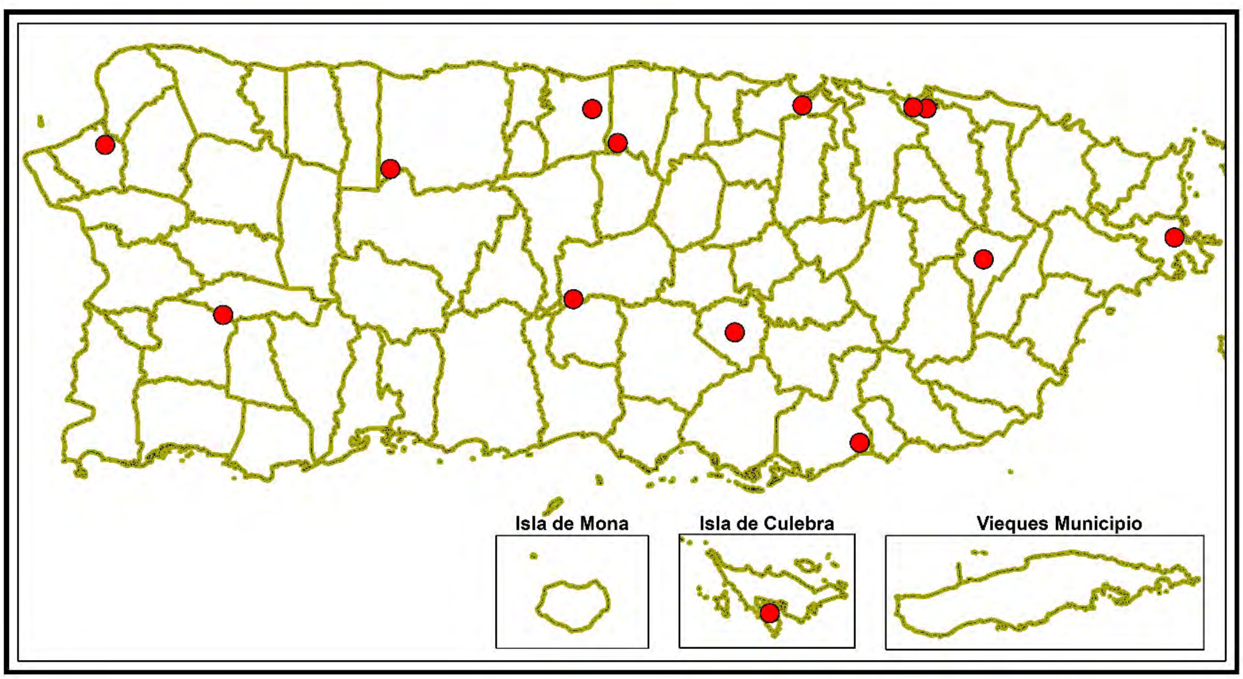

Figure 29: Weather Stations Collecting Daily Temperature Information

Hazard Frequency Analysis Results

Temperatures do not regularly exceed ninety-five degrees Fahrenheit (95°F) across Puerto Rico making heat hazard less impactful than other hazard types. Two (2) areas of Puerto Rico, one (1) in the northwest and one (1) along the northcentral coastline exhibit higher average instances of heat hazard days with one to two (1 – 2) days per year (see map below). The remainder of Puerto Rico is characterized by low number of heat hazard days. In this regard, there are seven (7) municipalities with land area in the high heat hazard category and an additional six (6) with area in the medium high heat hazard category.

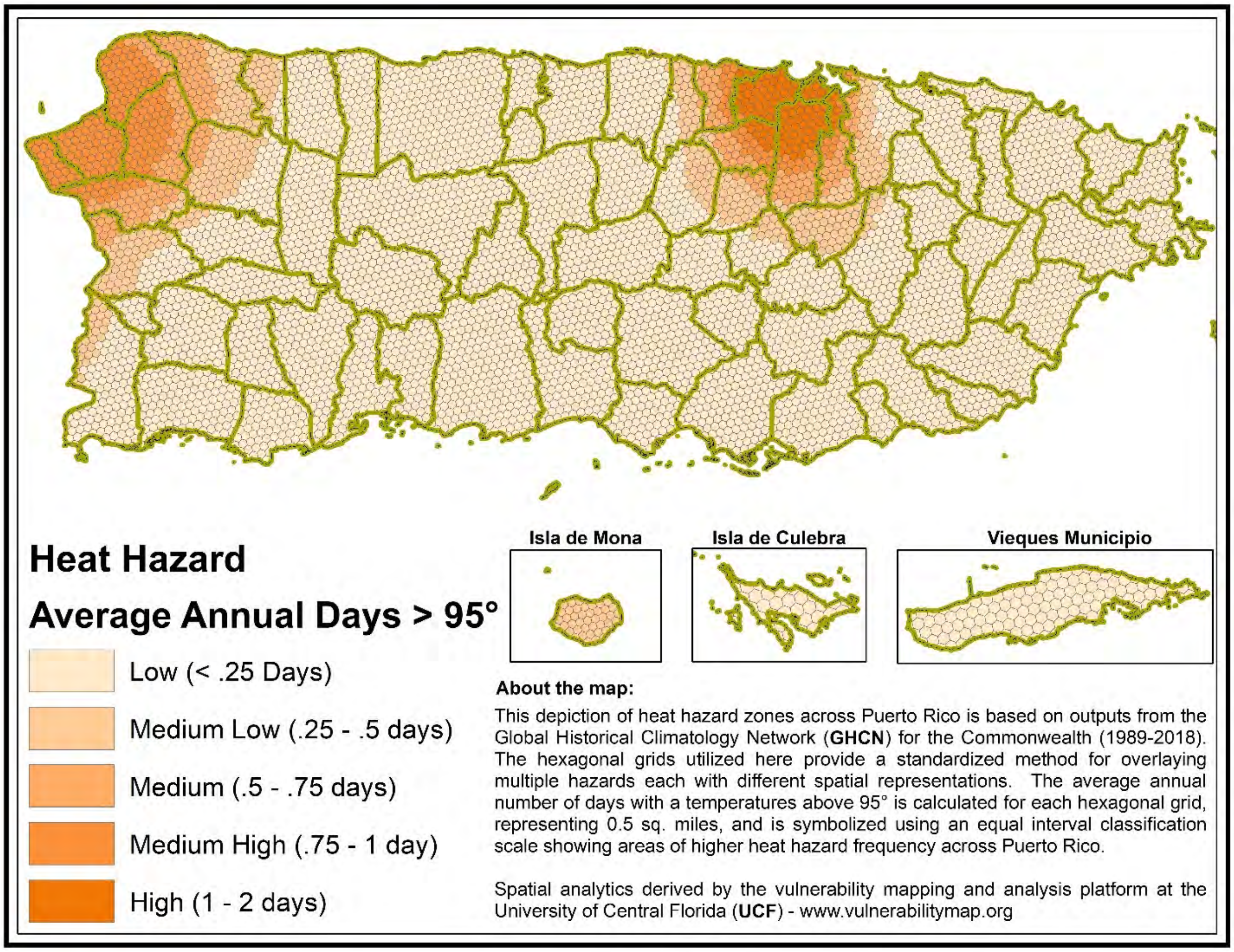

Figure 30: High Temperature Hazard Areas

Tornado

Hazard Overview

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud extending to the ground. It is most often generated by a thunderstorm and produced when cool, dry air intersects and overrides a layer of warm, moist air, forcing the warm air to rise rapidly. The damage from a tornado is a result of high wind velocity and wind-blown debris, although they are commonly accompanied by large hail as well. Tornadoes very rarely occur on Puerto Rico. Between 1959-2019 there have been only thirty-two (32) confirmed tornadoes across the Island.[60] However infrequent, tornadoes

[60] https://www.spc.noaa.gov/gis/svrgis/

can cause serious damage when they do occur. Tornados are characterized by intensity linked to post-disaster damages. Since 2007, the intensity of tornadoes is measured by the Enhanced Fujita-Pearson Scale. The most violent tornados have rotating winds of 200 miles per hour or more and can cause extreme destruction, including uprooting trees and well-made structures, and turning normally harmless objects into deadly missiles.

Data and Methods

Pinpointing past tornado occurrence provides a very limited understanding of tornado frequency and likely underestimates tornado threats. Utilizing tornado watch boxes, those areas where conditions were favorable for tornado development, provides a more nuanced understanding of historical hazard zones. For this assessment, tornado warning polygons (2002-2019) were obtained from National Weather Service Watches and Warnings through the Iowa Environmental Mesonet. A total frequency is calculated for each hexagonal grid as the number of tornado warning polygons that intersect each hexagon. Average annual frequency is then calculated by dividing the total frequency by the number of years in record.

Hazard Frequency Analysis Results

Western portions of the Island have historically had the largest number of tornado watches and warnings (see map on following page). San Sebastián, Mayagüez, Añasco, and Las Marías all have area in the high hazard class for tornados.

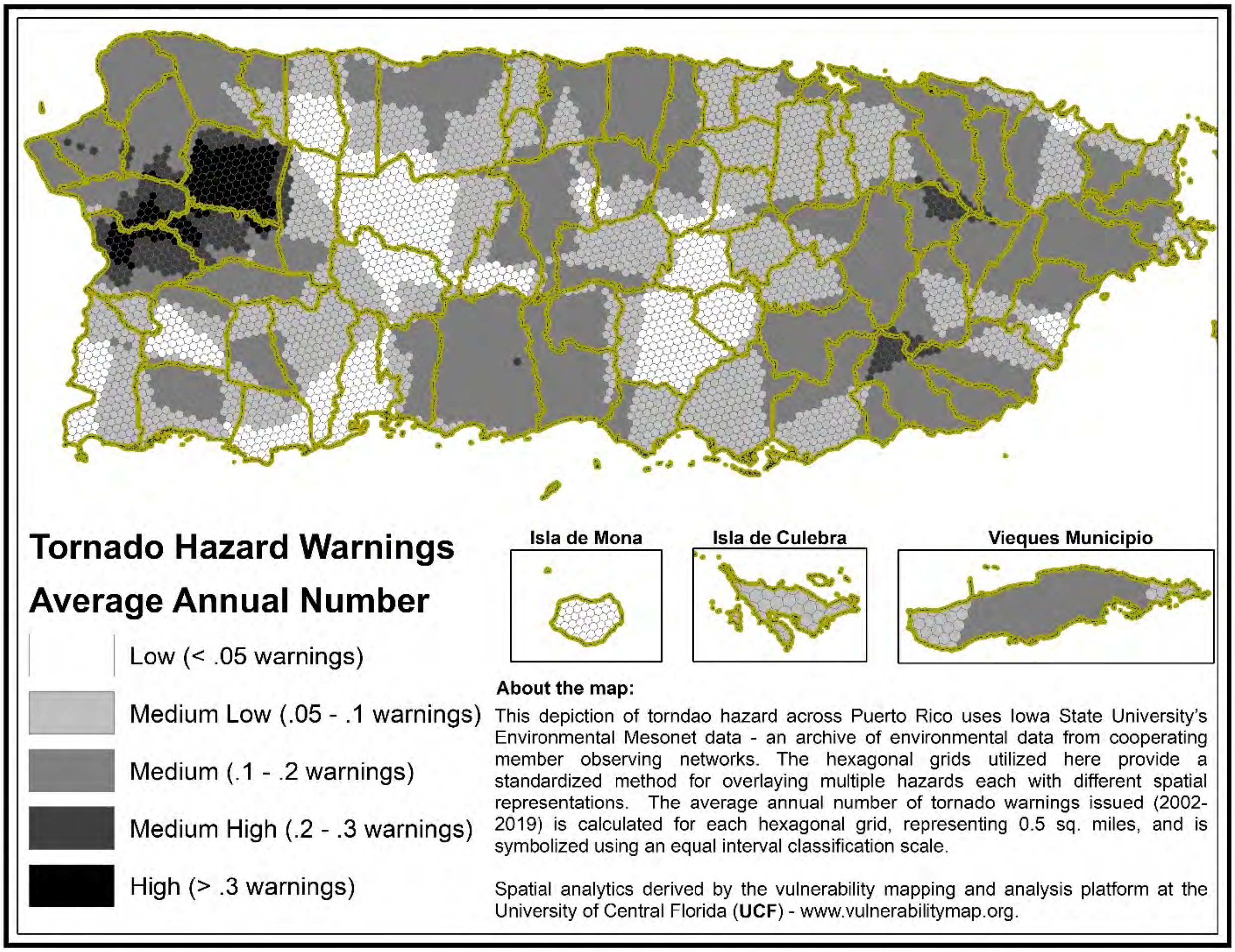

Figure 31: Tornado Hazard Areas

Wildfire

Hazard Overview

A wildfire is any type of forest, grass, brush, or outdoor fire that is not controlled or supervised. While wildfire occurrence and extent are generally controlled by climate, occurrence and extent of wildfires is also controlled by local factors such as ignition source, topography, local weather patterns, variations in fuel characteristics (type and condition), land-use practices, and overall management practices.[61] Across much of the Caribbean, wildfires tend to occur mainly in grasslands, croplands, or dry forest areas. Time of day, climate, and land cover have been the most significant drivers of wildfire across Puerto Rico. Irrespective of how they start or how they spread, wildfires pose a significant threat to lives and livelihoods across Puerto Rico.

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[61] Monmany, Ana Carolina; Gould, William; Andrade-Nunez, Maria Jose; Gonzales, Grizelle; Wuinones, Maya. "Characterizing Predictability of Fire Occurrences in Tropical Forests and Grasslands: The Case of Puerto Rico". Forest Ecology and Conservation. Chapter 4. InTech: Rijeka, DOI: 10.5772/63322. 2017. Accessed at: https://www.fs.usda.gov/treesearch/pubs/54146

Data and Methods

Like several other hazards in this assessment, wildfire extent data is not readily available for Puerto Rico from a national assessment such as the Monitoring Trends in Burn Severity (**MTBS**) database [62] or the USGS Geospatial Multi-Agency Coordination (**GeoMAC**), or the National Interagency Fire Center[63]. For this assessment, barrio-level wildfire occurrence data associated with USDA and US Forest Service Research on wildfire predictability was provided for use by UDA Caribbean Climate Hub.[64] The average annual number of wildfire events (2003 – 2011) for each barrio was first calculated and then spatially joined with the Puerto Rico hexagonal grid to create a representation of wildfire hazard threat across Puerto Rico.

Hazard Frequency Analysis Results

Wildfire threat is higher across southern Puerto Rico than the remainder of the Island (see map on following page). Three (3) municipalities (Guayama, Salinas, and Santa Isabel) have high historical wildfire frequency using the classifications scheme provided by Monmany et al. (2017).[65]

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[62] Monitoring Trends in Burn Severity. Wildfire Data. Accessed at: https://www.mtbs.gov/
[63] National Interagency Fire Center. Accessed at: https://www.nifc.gov/
[64] Data provided by Dr. William Gould – Research Ecologist and Director of the USDA Caribbean Climate Hub
[65] Monmany, Ana Carolina; Gould, William; Andrade-Nunez, Maria Jose; Gonzales, Grizelle; Wuinones, Maya. "Characterizing Predictability of Fire Occurrences in Tropical Forests and Grasslands: The Case of Puerto Rico". Forest Ecology and Conservation. Chapter 4. InTech: Rijeka, DOI: 10.5772/63322. 2017. Accessed at: https://www.fs.usda.gov/treesearch/pubs/54146

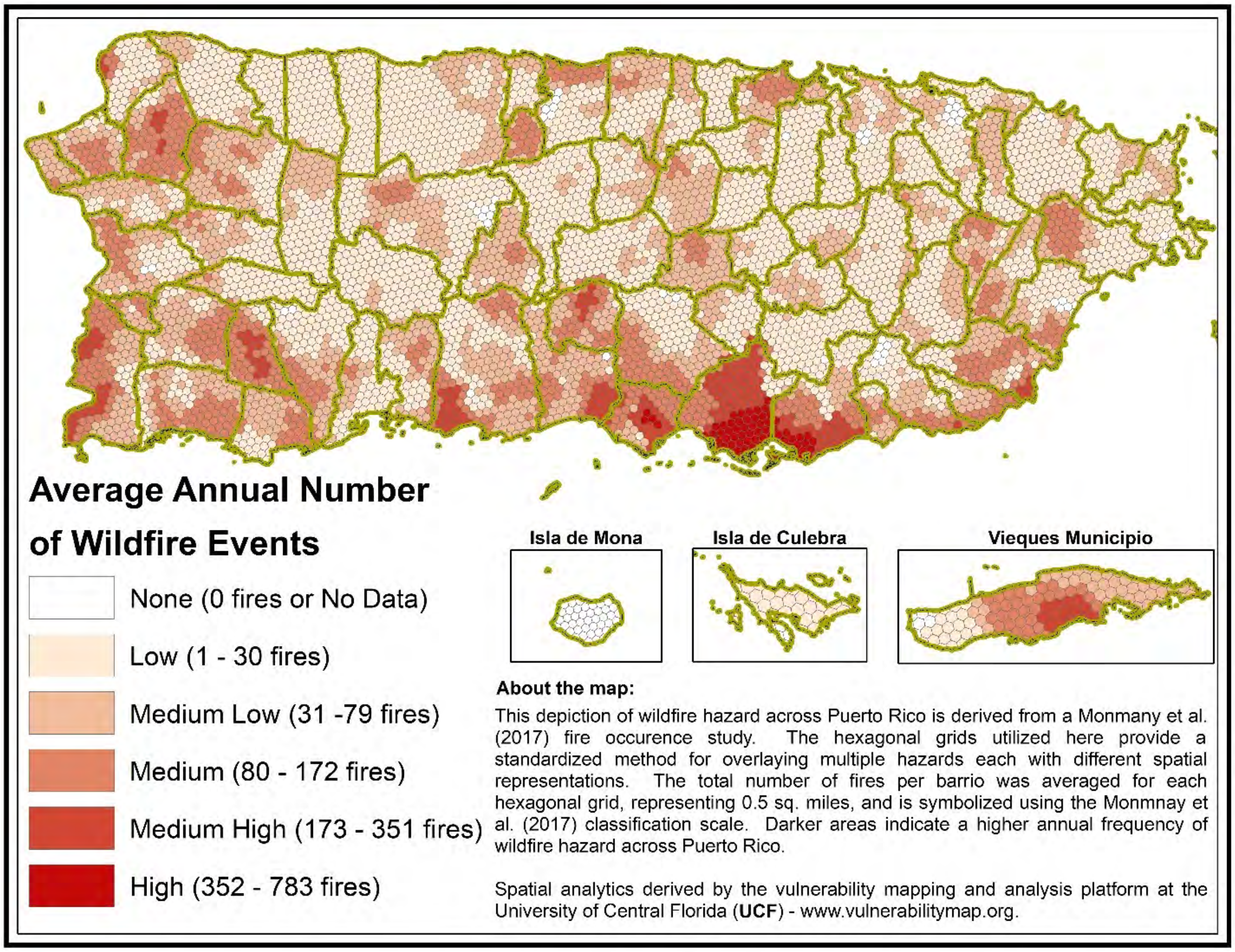

Figure 32: Wildfire Hazard Areas

Human Caused Hazards

Hazard Overview

Human induced hazards, including chemical spills and terrorist incidents, have the capacity to impact lives and livelihoods in many of the same ways natural hazards do. For the purposes of this assessment, terrorism is officially defined (by the Federal Bureau of Investigation) as "...the unlawful use of force and violence against persons or property to intimidate or coerce the government, the civilian population or any segment thereof, in the detriment of achieving political or social objectives."[66] The term technological hazard refers to incidents arising from human activities such as manufacturing, transportation, storage and use of hazardous materials. While terrorist events are not

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[66] US Department of Justice, Federal Bureau of Investigation, *Terrorism in the United States* 2002 – 2005. Accessed at: https://www.fbi.gov/stats-services/publications/terrorism-2002-2005

accidental, FEMA presumes that chemical spills and other technological events are accidental and unintentional.[67]

Data and Methods

Terrorist incidents (1970-2018) collected from the global terrorism database and transportation incidents resulting in chemical spills (2005-2019) collected from the Pipeline and Hazardous Materials Safety Administration were summarized at the city level across Puerto Rico and annual frequencies for each were calculated. Resulting polygons representing the spatial distribution of human-caused hazard frequencies were intersected with the hexagonal grid and the maximum frequency between terrorist events and chemical spills was transposed to the hex grid as a representation of annual frequency.

Hazard Frequency Analysis Results

San Juan and Carolina stand out with the largest historical number of terrorism and transportation accidents, followed by Caguas, Aguadilla, Cataño, and Guaynabo. San Juan and Carolina each have a large amount of land representing greater than sixty percent (60%) of their land area in high human hazard zones. This pattern continues when looking at the total Island-wide land area and places these municipalities at the top in terms of overall human hazard score and ranks.

[67] FEMA. Integrating Management Hazards Into Planning. September 2003. Accessed at: https://www.fema.gov/media-library-data/20130726-1524-20490-3869/howto7.pdf

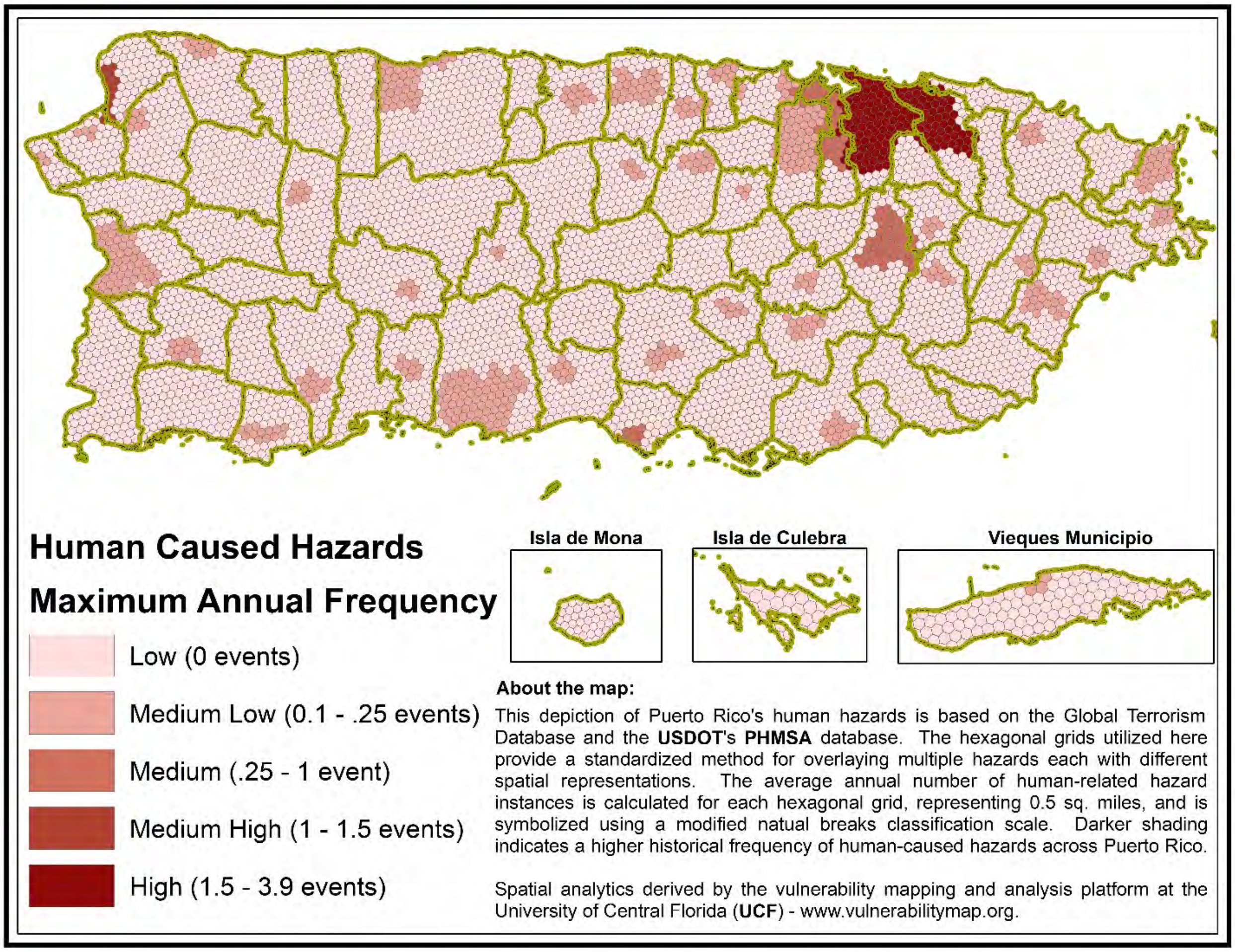

Figure 33: Human Caused Hazard Areas

Liquefaction

Hazard Overview

Liquefaction is a phenomenon causing unconsolidated soils to lose strength and act similar to viscous fluid when subjected to earthquake ground shaking. Liquefaction can result in subsidence of land during an earthquake event. Liquefaction frequency and intensity is based on several factors, including the geologic conditions of the area, groundwater depth, ground shaking intensity, and the magnitude of the earthquake.[68]

Data and Methods

Universidad Metropolitana (**UMET**), in partnership with URS Corporation, completed an integrated hazard assessment for Puerto Rico (2002). One output of this work was an assessment of liquefaction-induced ground failure potential hazard zones across most of Puerto Rico (excluding Vieques, Culebra, and Isla de Mona). Relative liquefaction susceptibility was characterized by evaluating soil/geologic conditions and groundwater

[68] Geoinformatica, Inc., Accessed at: http://www.geopr.org/free-data.html

depth. Based on these characteristics, a relative liquefaction susceptibility rating (e.g., very low to very high) was assigned based on classification systems established by Youd and Perkins (1978).[69] Sandy soils with shallower water tables, present a greater liquefaction threat than rock or rock-like materials which were considered low liquefaction hazards. These zones, originally created for each municipality, were combined and mapped using the same classification system as in the initial assessment.

Hazard Frequency Analysis Results

Largely a coastal and river basin phenomenon, liquefaction hazard zones can be found in nearly every contiguous municipality across Puerto Rico. Each municipality, with the exception of Maricao in Western Puerto Rico, has at least some areas with greater than low liquefaction hazard potential (see map below).

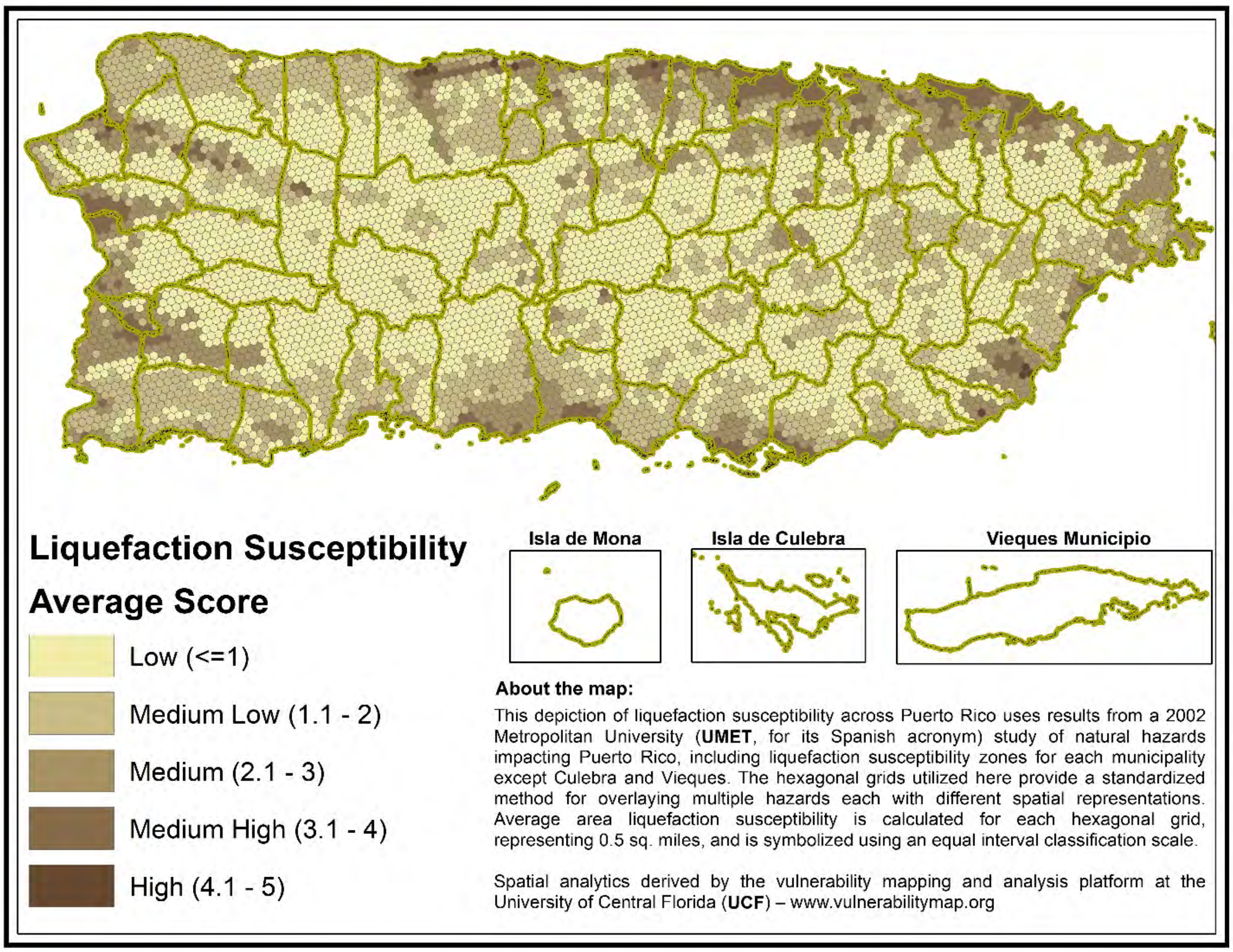

Figure 34: Liquefaction Hazard Areas

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[69] Youd, Leslie, ASCE, M. Perkins, David M., "Mapping Liquefaction-Induced Ground Failure Potential", *Journal of the Geotechnical Engineering Division*. April 1978. Accessed at: https://www.researchgate.net/profile/T_Youd/publication/279600523_Mapping_liquefaction-induced_ground_failure_potential/links/5733901f08aea45ee838f8f2.pdf

Lightning

Hazard Overview

All thunderstorms produce lightning, a spark of static electricity, that results from the buildup of electrical energy between positively and negatively charged areas. Whenever thunder is audible, there is the risk of a lightning strike. The only safe place during a thunderstorm is inside. Lightning has also occurred in volcanic eruptions, intense forest fires, surface nuclear detonations, heavy snowstorms, and in large hurricanes. There are four (4) types of lightning: cloud to ground, intra-cloud, cloud-to-cloud, and cloud to air. The term "heat lightning" is a misnomer and is not related to high temperatures. Heat lightning is lightning that is simply too far away for the thunder to be audible. Cloud-to-ground lightning is responsible for most fatalities, injuries, and property damage.

Data and Methods

The lightning data (2010-2019), obtained from the World Wide Lightning Location Network.[70] provide locations in latitude and longitude (decimal degree) of cloud-to-ground lightning strikes. These strike locations were plotted as points, overlaid by the 0.5-mile hexagonal grid and a count of strikes was generated for each hex grid. Annual lightning frequency, calculated as the number of lightning points that are intercepted with each hexagon divided by the total number of years in record, provides a spatial representation of lightning hazard across Puerto Rico.

Hazard Frequency Analysis Results

Although lightning can occur anywhere in Puerto Rico, western portions of the Island have a higher lightning strike frequency than other areas (see map below).

[70] World Wide Lightning Location Network. Accessed at: http://wwlln.net/

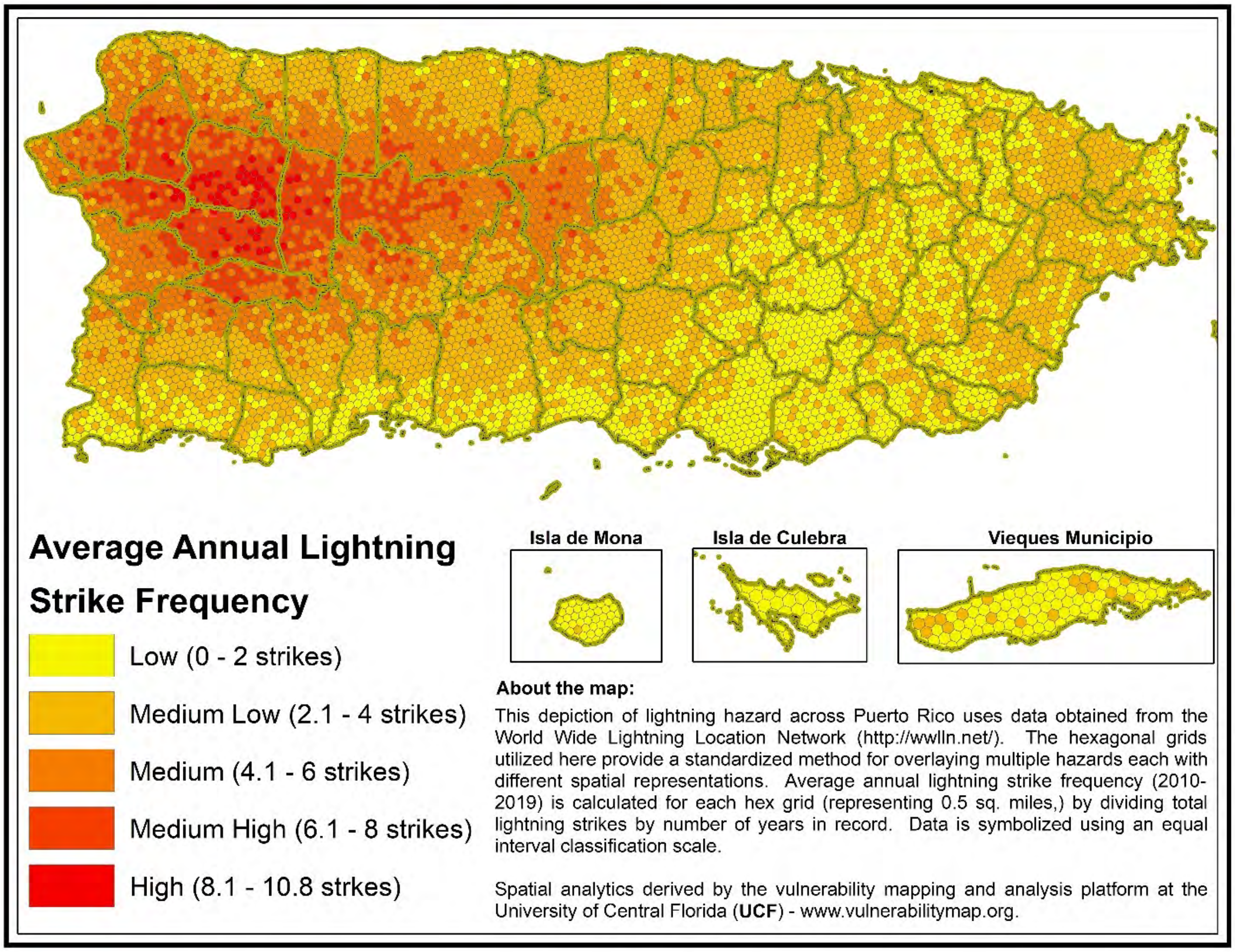

Figure 35: Lightning Hazard Areas

Sea-Level Rise

Hazard Overview

Sea level rise is an increase in the level of the world's oceans due to the effects of global warming and land subsidence. As ocean water becomes warmer, it expands. This results in ocean levels rising worldwide.[71] Global sea level has been rising over the past century, and the rate has increased in recent decades. In 2014, the global sea level was 2.6 inches above the 1993 average—the highest annual average in the satellite record (1993-present). Sea level continues to rise at a rate of about one-eighth (1/8) of an inch per year.[72] Sea level rise poses a significant threat to people living and working in coastal areas.

[71] National Geographic. "Seal Level Rise". Accessed at: https://www.nationalgeographic.org/encyclopedia/sea-level-rise/

[72] US Department of Commerce. National Ocean Service. "Is seal level rising?". Accessed at: https://oceanservice.noaa.gov/facts/sealevel.html

Data and Methods

Three scenarios of future sea-level rise, created by NOAA[73], were utilized in this assessment: A low scenario (one (1) foot), A moderate scenario (four (4) feet), and a high scenario (ten (10) feet) of sea level rise above Mean Higher High-water levels.[74] Like the flooding hazard, the percentage of land area spatially inside NOAA SLR zones was calculated for each 0.5-mile hex grid across Puerto Rico. These were classified using an equal interval classifications scheme allowing users to clearly see where sea-level rise threatens the coastline.

Hazard Frequency Analysis Results

Like hurricane storm surges, sea level rise impacts are largely a coastal phenomenon with the Island's northern shore seeing the heaviest potential impacts. However, impacts on all coastal Puerto Rico are clearly evident across all three (3) scenarios with the ten (10)-foot inundation creating the largest spatial impact (see maps on following pages for one (1) foot, four (4) foot, and ten (10) foot SLR zones). For each sea level rise scenario, the NOAA model indicates a differing amount of land area inundated in each municipality. As a result, the percentage of each municipality's land area changes for each scenario. The percent of each municipality's total island-wide land area also changes for different sea level rise scenarios. Finally, a table showing municipality scores and ranks for each scenario provides a perspective on which areas of the Island are more highly threatened by potential sea level rise conditions.

[73] US Department of Commerce. National Ocean Service. Data Download. Accessed at: https://coast.noaa.gov/slrdata/
[74] US Department of Commerce. National Ocean Service. Tidal Datums. Accessed at: https://tidesandcurrents.noaa.gov/datum_options.html

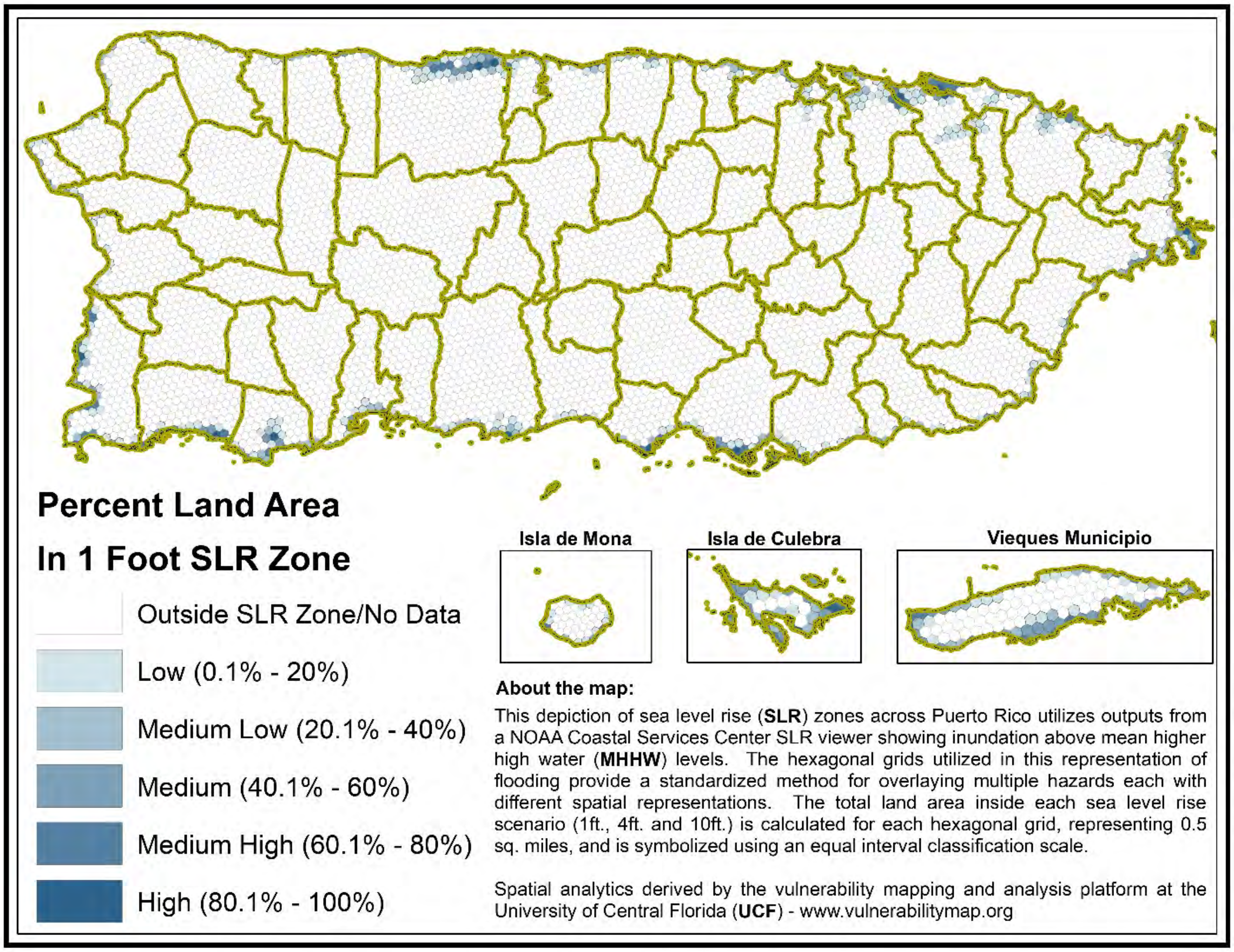

Figure 36: Sea Level Rise (1 foot) Hazard Areas

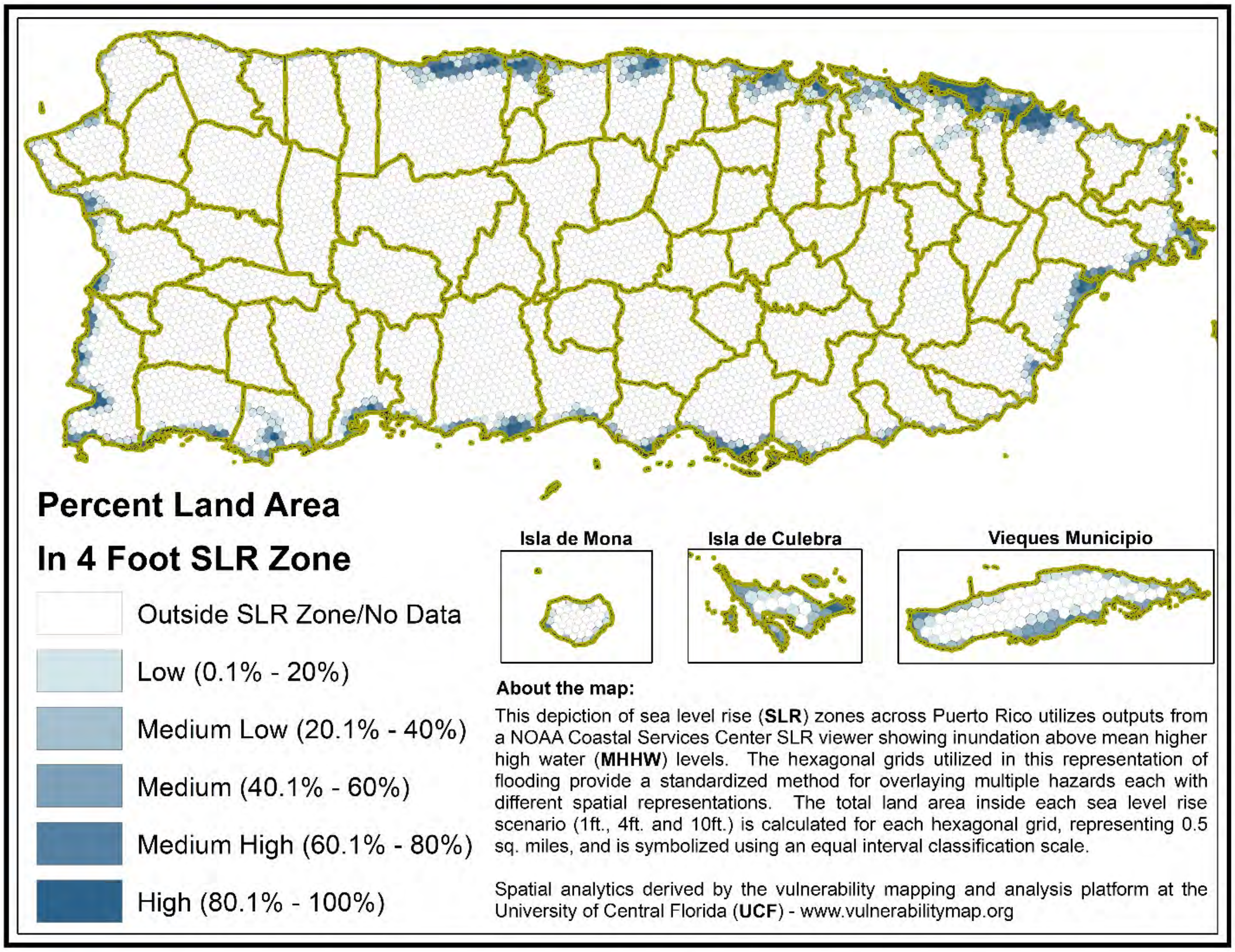

Figure 37: Sea Level Rise (4 feet) Hazard Areas

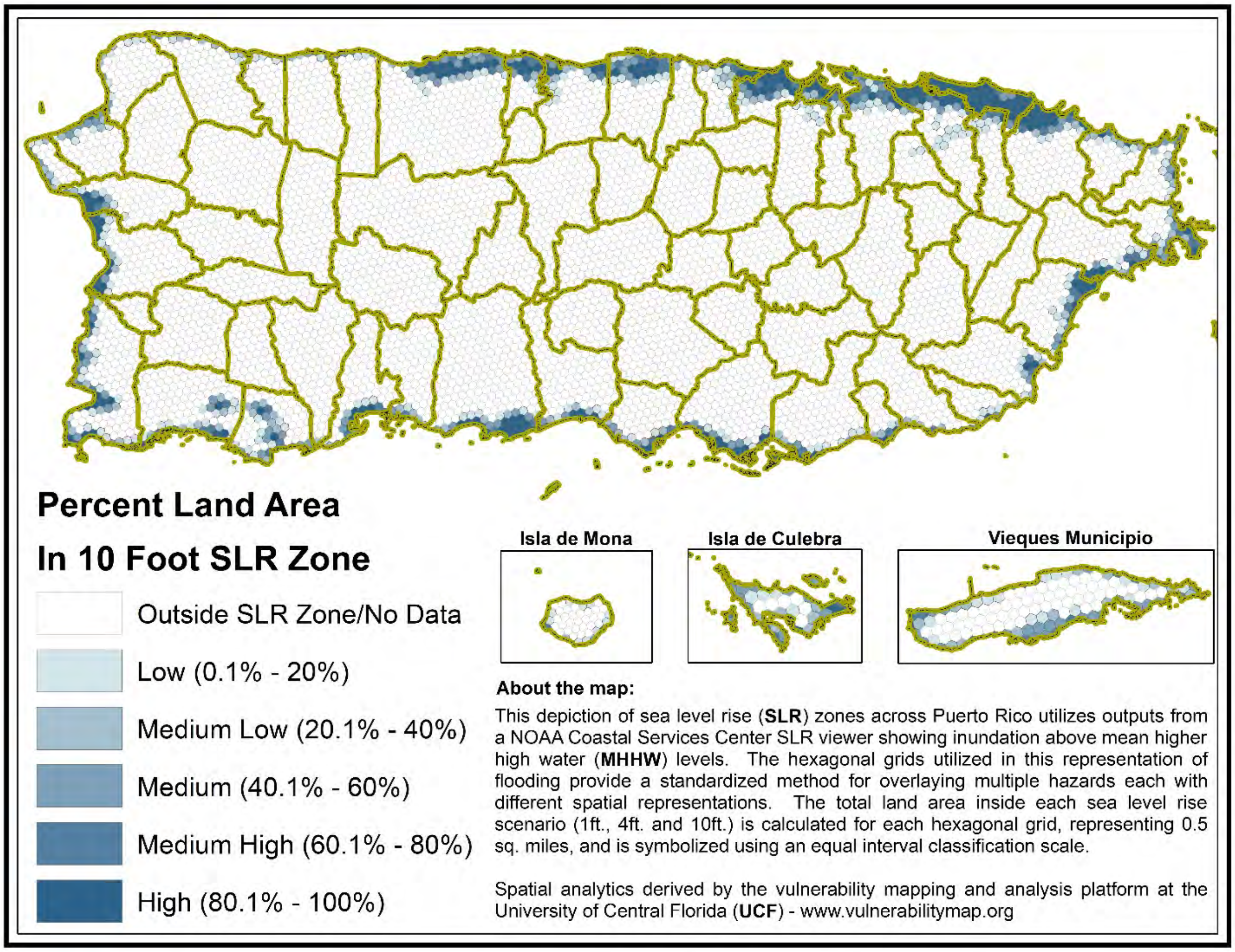

Figure 38: Sea Level Rise (10 feet) Hazard Areas

RISK ANALYSIS

RISK ANALYSIS BASED ON COMMUNITY LIFELINES

Community Lifelines are defined by FEMA as functions that enable the continuous operation of critical government and business functions and are essential to human health and safety or economic security. Lifelines are the integrated network of assets, sectors, services, and capabilities that are used day-to-day to support the recurring needs of the community. Lifelines also represent an organizing principal for resource allocation and prioritization during and after a disaster. FEMA identifies seven (7) lifelines as the following:

1. Safety and Security;
2. Food, Water and Shelter;
3. Health and Medical;
4. Energy;
5. Communications;
6. Transportation; and
7. Hazardous Materials.

Within each of the seven (7) lifelines, there exist sectors and subsectors. The key sectors of each lifeline are shown in the FEMA lifeline graphic below.

Figure 39. FEMA Community Lifelines and Sectors. Critical Lifelines and Sectors are depicted by darker icons.

Early in the planning process, ninety (90) open source GIS data layers identifying the geolocation and key metadata for infrastructure assets were mapped for all seven (7) lifelines. These data layers were loaded into PRDOH GIS tools for increased planning capacity. Geospatial information for the key sectors within four (4) critical lifelines has been compiled and made accessible to communities and citizens of Puerto Rico in the *PR Critical Lifeline - Regional Dashboard* – which is a publicly available dashboard tool (shown below). The dashboard will remain available on the CDBG-MIT website in English and Spanish at https://cdbg-dr.pr.gov/en/cdbg-mit/ and https://cdbg-dr.pr.gov/cdbg-mit/.

Figure 40. Image of Regional Dashboard depicting geoloaction of critical lifeline infrastructure.

ANALYSIS OF VULNERABILITY

Understanding which populations and what assets are likely to be impacted by hazard events is critical for developing sound mitigation planning activities and projects. Here, vulnerability is defined by combining three (3) different indicators:

1. Critical lifeline infrastructure assets provide a representation of what is at risk;
2. Socially vulnerable areas provide an idea of who has a lower capacity to absorb shocks and stresses; and
3. Total population supports a utilitarian approach to serving the greatest number of people.

Combining these three (3) vulnerability indicators into a single measure, enables an accounting of all three (3) characteristics in an empirical way. The vulnerability was determined by developing a GIS inventory of critical infrastructure assets[75], population[76], and socially vulnerable population.

Lifeline infrastructure assets considered critical lifeline sectors include facilities for transportation, communication, water and wastewaters, and power. These facilities are most critical because all other infrastructure lifelines depend on them for stability.[77] Socially vulnerable populations were derived from the Social Vulnerability Index (**SoVI**) first developed by Cutter (2003)[78] and later refined by scholars at the University of Central Florida[79]. Understanding where populations reside who have a reduced ability to

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[75] United State. FEMA. "Community Lifelines". Accessed at: https://www.fema.gov/lifelines
[76] Population has been calculated utilizing FY 2020 ACS 5-Year 2011-2015 Low- and Moderate-Income Summary Data Block Group data for Puerto Rico and Census TIGER/Line Shapefiles.
[77] See Lifeline Interdependency section for more information.
[78] https://onlinelibrary.wiley.com/doi/abs/10.1111/1540-6237.8402002
[79] www.vulnerabilitymap.org

prepare for, respond to, and recover from disaster events can help decision makers distribute scarce resources before, during, or after disasters. The population density was derived from the HUD low- and moderate-income summary data (**LMISD**) at the block group level. Each of the three (3) components of vulnerability used here are summarized in the sections that follow.

1 – Critical Lifeline Infrastructure

Lifeline Infrastructure assets considered for the analysis include those lifelines sectors that have been determined the most critical to the stability and resilience of Puerto Rico. Critical Lifeline infrastructure assets across the Island were therefore assessed using the four (4) categories of interdependent lifeline assets in the lifelines of Energy, Communications, Transportation, and Food, Water and Shelter.[80] with the understanding that:

- Lifelines enable the continuous operation of critical government and business functions and are essential to human health and safety or economic security.
- Lifelines are the most fundamental services in the community that, when stabilized, enable all other aspects of society to function.
- FEMA has developed a construct for an objectives-based response that prioritizes the rapid stabilization of community lifelines after a disaster.
- The integrated network of assets, services, and capabilities that provide lifeline services are used day-to-day to support the recurring needs of the community and enable all other aspects of society to function.
- When disrupted, decisive intervention (e.g., rapid re-establishment or employment of contingency response solutions) is required to stabilize the incident.

Critical lifeline infrastructure considered is shown in the table below with a hyperlink to the public data sets utilized for the analysis.

[80] See Lifeline Interdependencies section of this draft for more information.

Critical Lifeline Infrastructure Included in Puerto Rico's Hazard Risk Assessment			
Critical Lifeline Infrastructure Asset	**Data Source**	**URL**	**Date Accessed**
Water/Wastewater Lines	PRASA	(no public link available)	2/25/2020
Water/Wastewater Facilities	PRASA	(no public link available)	2/25/2020
Power Plants	Homeland Infrastructure Foundation-Level Data (HIFLD)	https://hifld-geoplatform.opendata.arcgis.com/	4/16/2020
Electric Power Transmission Lines	Homeland Infrastructure Foundation-Level Data (HIFLD)	https://hifld-geoplatform.opendata.arcgis.com/	4/16/2020
PR Roads	United State Census Bureau	https://www.census.gov/cgi-bin/geo/shapefiles/index.php	4/16/2020
Major Ports	Homeland Infrastructure Foundation-Level Data (HIFLD)	https://hifld-geoplatform.opendata.arcgis.com/	4/19/2020
Ports	Homeland Infrastructure Foundation-Level Data (HIFLD)	https://hifld-geoplatform.opendata.arcgis.com/	4/19/2020
Airports	Homeland Infrastructure Foundation-Level Data (HIFLD)	https://hifld-geoplatform.opendata.arcgis.com/	4/19/2020
Broadband Radio and Educational Broadband Radio	Homeland Infrastructure Foundation-Level Data (HIFLD)	https://hifld-geoplatform.opendata.arcgis.com/	4/22/2020
FM Radio Towers	Homeland Infrastructure Foundation-Level Data (HIFLD)	https://hifld-geoplatform.opendata.arcgis.com/	4/22/2020
Land Mobile Radio Stations	Homeland Infrastructure Foundation-Level Data (HIFLD)	https://hifld-geoplatform.opendata.arcgis.com/	4/22/2020
AM Radio Transmitters	Homeland Infrastructure Foundation-Level Data (HIFLD)	https://hifld-geoplatform.opendata.arcgis.com/	4/22/2020
Cellular Radio Towers	Homeland Infrastructure Foundation-Level Data (HIFLD)	https://hifld-geoplatform.opendata.arcgis.com/	4/22/2020
Microwave Radio Transmitters	Homeland Infrastructure Foundation-Level Data (HIFLD)	https://hifld-geoplatform.opendata.arcgis.com/	4/22/2020

Critical Lifeline Infrastructure Density

Critical lifeline infrastructure locations are captured and mapped using either point features (individual locations) or line features (sets of point features) depending on the infrastructure asset. For example, electric generation facilities would be represented by a point, while electrical transmission lines would be represented as line features inside a GIS system. For this assessment, line feature classes representing critical infrastructure were converted to point feature classes using the ESRI ArcGIS Pro Generate Points Along Lines tool generating a point at each endpoint and every 200 meters along the line feature. Critical infrastructure point data and point data generated from the line features were then merged to create one (1) complete point feature representation of critical infrastructure. This point data was then geo-processed with the ESRI ArcGIS Pro Summarize Within tool to generate a count of points within each 0.5-square-mile hex grid. Critical lifeline infrastructure counts were then classified using an equal interval classifications scheme and mapped using the same output hex grid as the hazard threat maps (see map below).

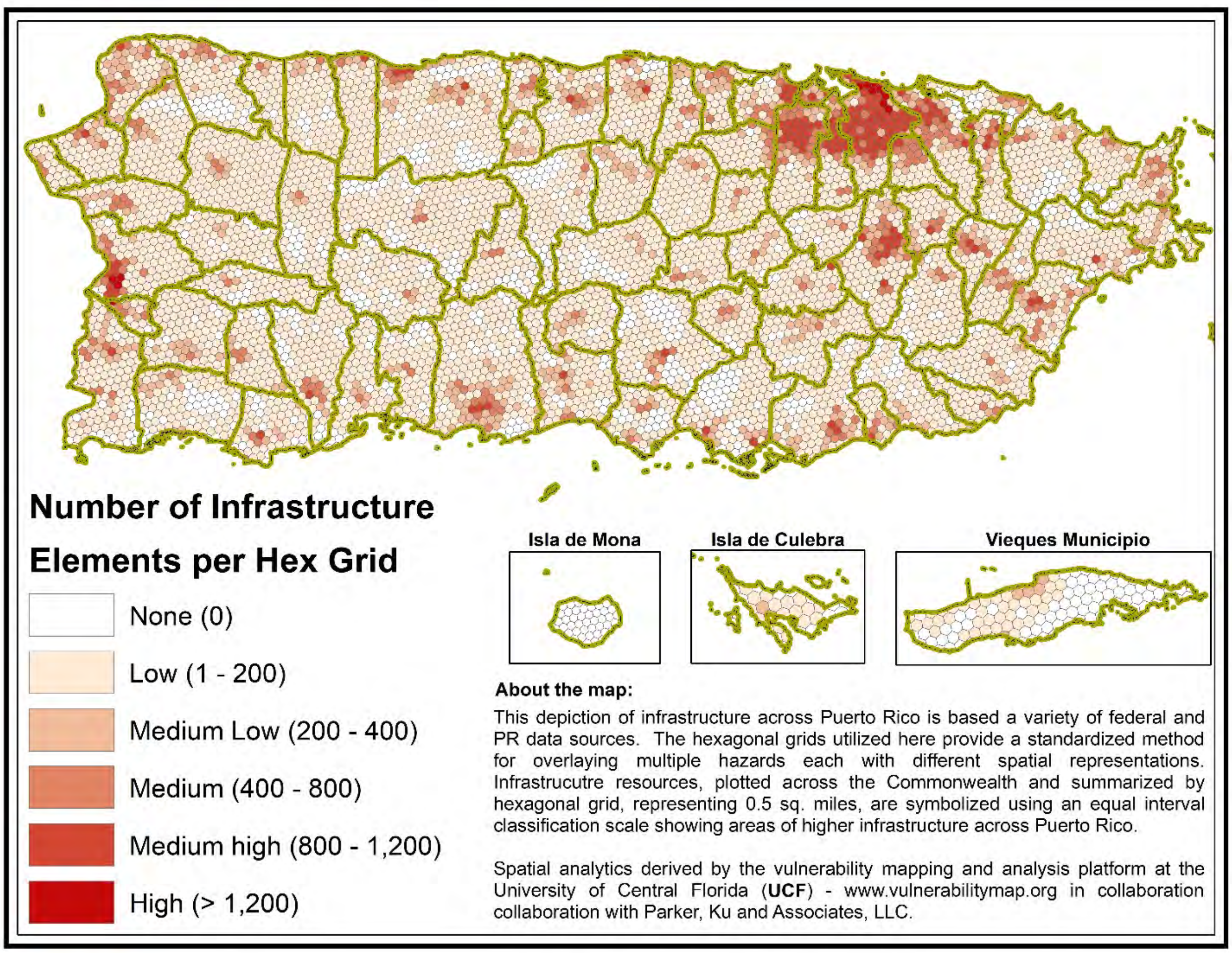

Figure 41: Puerto Rico's Critical Infrastructure Elements gathered using FEMA's lifeline guidance.

2 – Social Vulnerability

Social vulnerability describes an area's capacity to prepare for, respond to, and rebound from disaster events[81], and has a long conceptual and theoretical history in social and disaster science fields.[82] Socially vulnerable populations have fewer resources to aid in preparation for disasters, often bear the brunt of disaster impacts, and take longer to bounce back from disaster events. Empirical measures of social vulnerability enable decision makers and emergency managers to understand where vulnerable populations reside and how that vulnerability manifests across a landscape. The twenty-nine (29) criteria utilized for this analysis are described in the table below.[83]

Social Vulnerability Index Factors		
Variable	**Description**	**Pillar**
1	Percent Civilian Unemployment	Employment Structure
2	Percent Employment in Extractive Industries	Employment Structure
3	Percent Employment in Service Industry	Employment Structure
4	Percent Female Participation in Labor Force	Employment Structure
5	Percent Renters	Housing
6	Percent Mobile Homes	Housing
7	Percent Unoccupied Housing Units	Housing
8	Percent Population under 5 years or 65 and over*	Population structure
9	Percent of Children Living in 2-parent families	Population structure
10	Median Age	Population structure
11	Percent Female*	Population structure
12	Percent Female Headed Households*	Population structure
13	People per Unit	Population structure
14	Percent Asian*	Race/Ethnicity
15	Percent Black*	Race/Ethnicity
16	Percent Hispanic*	Race/Ethnicity
17	Percent Native American*	Race/Ethnicity
18	Percent Poverty	Socioeconomic Status

[81] Cutter, Susan L., Emrich, Christopher T., "Moral Hazard, Social Catastrophe: The Changing Face of Vulnerability along the Hurricane Coasts". The ANNALS of the American Academy of Political and Social Science. March 1, 2006. Accessed at: https://doi.org/10.1177/0002716205285515
[82] Birkmann, Jörn. "Measuring Vulnerability to Natural Hazards: Towards Disaster Resilient Societies Second Edition. United National University Press. December 2013. Accessed at: https://unu.edu/publications/books/measuring-vulnerability-to-natural-hazards-towards-disaster-resilient-societies-second-edition.html#overview
[83] Additional information about SoVI criteria can be found at www.vulnerabilitymap.org.

Social Vulnerability Index Factors		
Variable	**Description**	**Pillar**
19	Percent Households Earning over $200,000 annually	Socioeconomic Status
20	Per Capita Income	Socioeconomic Status
21	Percent with Less than 12th Grade Education	Socioeconomic Status
22	Median Housing Value	Socioeconomic Status
23	Median Gross Rent	Socioeconomic Status
24	Percent of households spending more than 40% of their income on rent or mortgage	Socioeconomic Status
25	Percent Households Receiving Social Security Benefits	Special Needs
26	Percent Speaking English as a Second Language with Limited English Proficiency	Special Needs
27	Nursing Home Residents Per Capita	Special Needs
28	Percent of population without health insurance	Special Needs
29	Percent of Housing Units with No Car	Special Needs

**** indicates a characteristic tied to a protected class under The Civil Rights Act of 1991 (Pub. L. 102-166).[84]***

These indicators of social vulnerability were used to create a SoVI for Puerto Rico. SoVI scores were categorized from (0 – no data to 5 – high social vulnerability) using a standard deviation classification scheme (see map on following page).

[84] In addition to considering protected class individuals in the SoVI analysis, PRDOH will also consider during implementation how assistance impacts beneficiaries that are classified as a protected class and shall consider HUD resources on racially and ethnically concentrated areas of poverty as published here: https://hudgis-hud.opendata.arcgis.com/datasets/56de4edea8264fe5a344da9811ef5d6e_0?geometry=-68.905%2C17.630%2C-64.845%2C18.544.

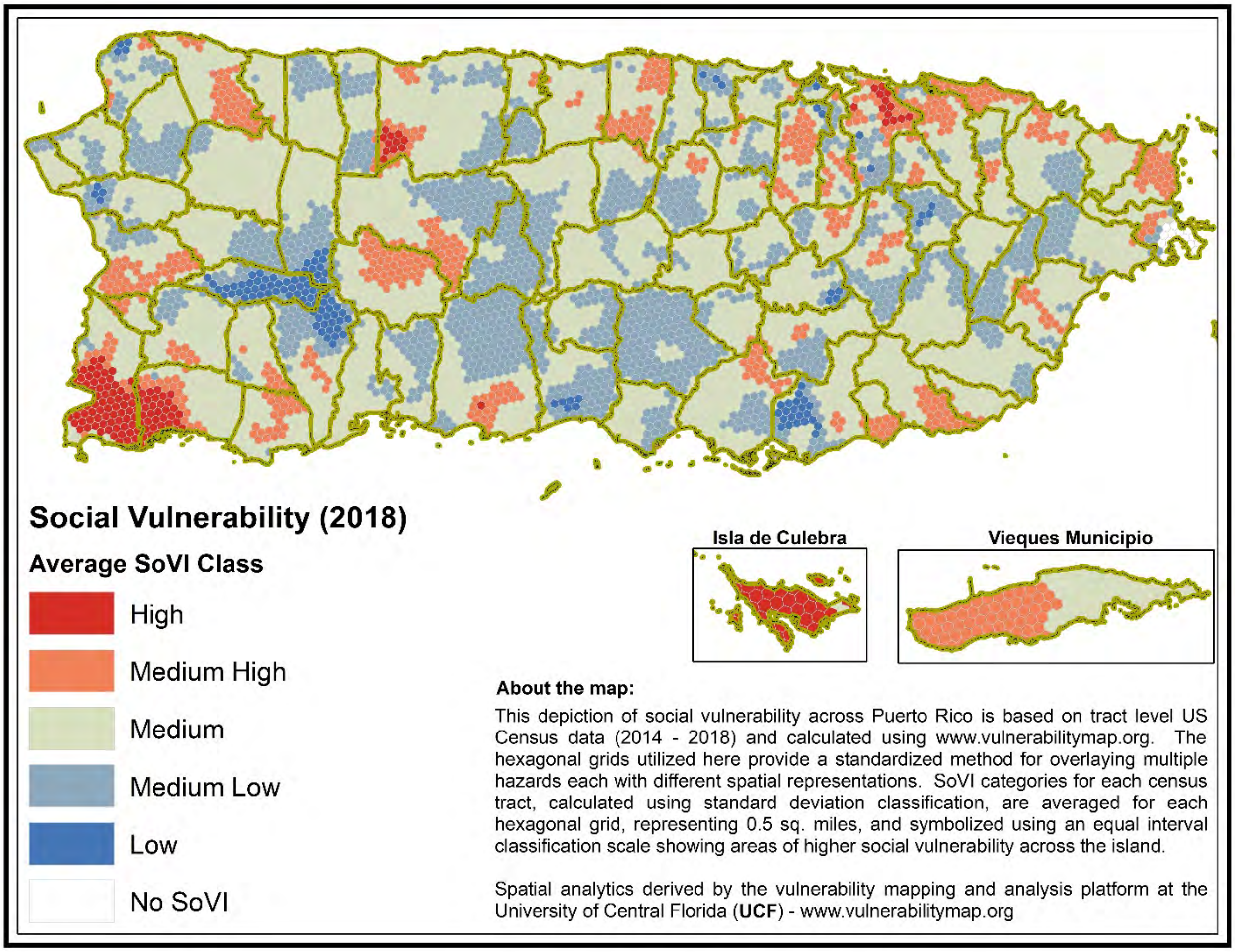

Figure 42: Puerto Rico's Social Vulnerability Index.[85]

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[85] Created from www.vulnerabilitymap.org

3 – Population Density

The map below is based on the population data collected from the American Community Survey products developed for HUD's LMISD block group dataset at the block group level.[86] This population data was geo-processed with the ESRI ArcGIS Pro Create Random Points tool to randomly distribute the population (Low- Moderate Universe). Similar to critical infrastructure, this population data was geo-processed with the ESRI ArcGIS Pro-Summarize Within tool, to generate a count of points within each 0.5-square-mile hex grid. The population per hex grid was classified on a quasi-exponential classification scale, showing areas with higher populations across Puerto Rico (see map below).

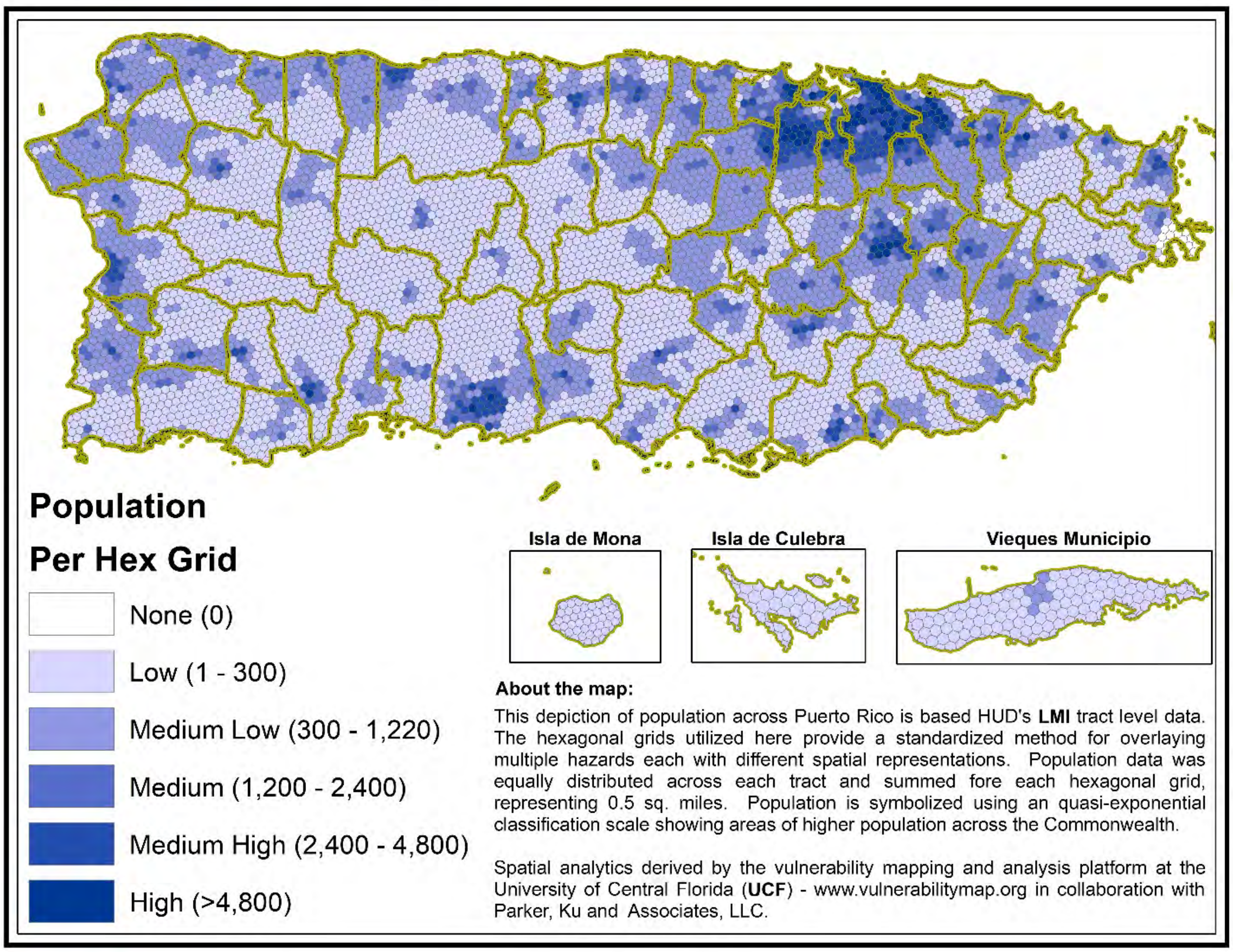

Figure 43: Puerto Rico's Population Distribution

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[86] United States. HUD. "LMISD- All Block Groups, Based on 2011-2015 ACS. Accessed at: https://www.hudexchange.info/programs/acs-low-mod-summary-data/acs-low-mod-summary-data-block-groups-places/

Hazard Vulnerability Composite Analysis

Each vulnerability variable (Critical Infrastructure Density, Social Vulnerability, and Population Density) was classified from zero (0) to five (5). The variables were then summed and divided by three (3) to develop a composite vulnerability score from zero (0) to five (5) (see Vulnerability Calculation equation and map below).

Equation 1: Vulnerability Calculation

$$VUL = \frac{(SoVI) + (INF) + (POP)}{3}$$

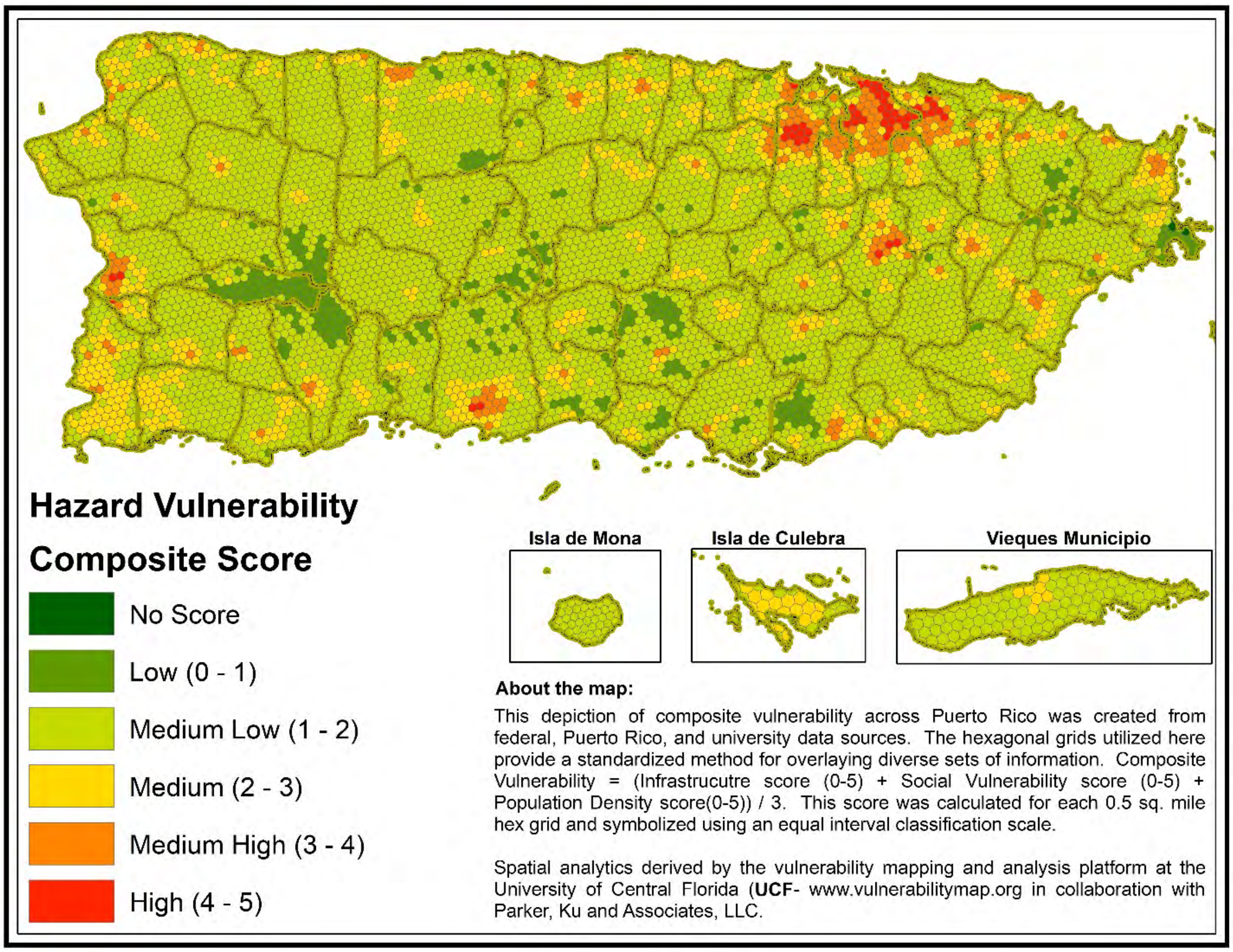

Figure 44: Puerto Rico's Composite Hazard Vulnerability

SEVERITY OF CONSEQUENCES

Each single hazard event and event type (flooding, hurricane, etc.) has a different severity of consequence. Creating a universal understanding of hazard risk for Puerto Rico required a robust accounting of consequences from historical losses as well as the ability to project future scenarios. To assess the risk, this report had to address possible climate sensitivities, current high priority hazards, and those likely to cause continued losses if not mitigated. Consequently, this assessment calculates, Severity of Consequences (see Severity of Consequence Calculation equation below) using equal parts Historical Consequence, Climate Sensitivity, a measure of probability versus consequence, and a measure of future impacts (or high priority hazards for Puerto Rico) derived from the Government of Puerto Rico's current Hazard Mitigation Plan.[87]

Equation 2: Severity of Consequences Calculation

$$CON_{HAZ_n} = (HISTORIC\ CONSEQUENCE) + (CLIMATE\ SENSITIVE) + (PROBABILITY\ CONSEQUENCE) + (FUTURE\ CONSEQUENCE)$$

HAZ= Flood, Earthquake, Landslide, Category-1 Storm Surge, Category-2 Storm Surge, Category-3 Storm Surge, Category-4 Storm Surge, Category-5 Storm Surge, Severe Storm, Tsunami, Drought, Wind, Fog, Hail, High Temperature, Lightning, Tornado, Wildfire, Sea Level Rise 1-foot, Sea Level Rise 4-foot, Sea Level Rise 10-foot, Liquefaction, Human Hazard, Hurricane Force Wind;

Historic Consequence

Hazard consequence is the sum of historical frequency, economic impacts, fatalities, and injuries from past disaster events.

Equation 3: Historical Consequence Calculation

$$HAZCON_{HAZ_n} = Historical\ Frequency\ Score + Historcal\ Economic\ Impacts\ Score + Historical\ Fatality\ Score + Historical\ Injury\ Score$$

Where:

Historical Frequency Score - a Min/Max standardized zero to one (0-1) indicator of recorded[88] frequency of occurrence for past loss causing Hazard (HAZ) events.

Historical Economic Impacts Score - a Min/Max standardized zero to one (0-1) indicator of recorded damages from past loss causing Hazard (HAZ) events.

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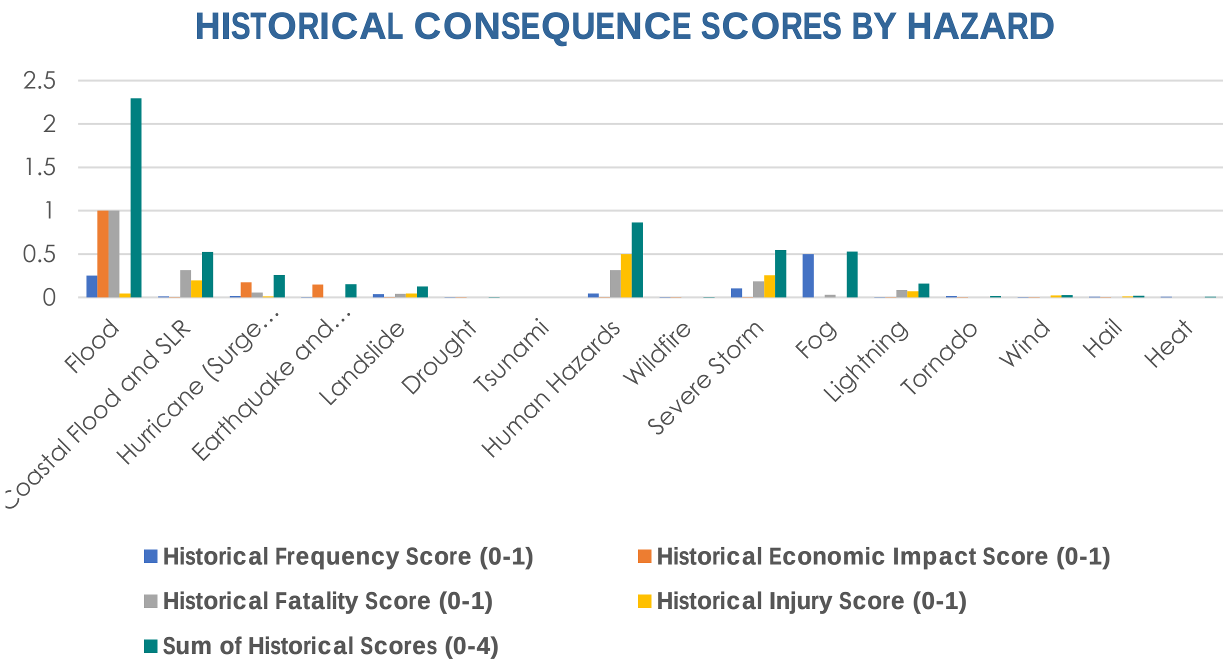
[87] 2016 Puerto Rico Hazard Mitigation Plan. Accessed under file name "Puerto Rico Plan de Mitigación-Aprobado 02/08/2016" at the following website location: https://recovery.pr/en/document-library.

[88] United Sates. NOAA. "Storm Events Database". Accessed at: https://www.ncdc.noaa.gov/stormevents/

Historical Fatality Score - a Min/Max standardized zero to one (0-1) indicator of recorded fatalities from past loss causing Hazard (HAZ) events.

Historical Injury Score (see table below) - a Min/Max standardized zero to one (0-1) indicator of recorded injuries from past loss causing Hazard (HAZ) events.

Historical Consequence Scores by Hazard					
Hazard	**Historical Frequency Score (0-1)**	**Historical Economic Impact Score (0-1)**	**Historical Fatality Score (0-1)**	**Historical Injury Score (0-1)**	**Sum of Historical Scores (0-4)**
Flood	0.251166	1	1	0.04651	2.29768
Coastal Flood and SLR	0.011552	0.00028	0.31429	0.19767	0.52379
Hurricane (Surge and Wind)	0.014625	0.17497	0.05714	0.01163	0.25836
Earthquake and Liquefaction	0.001378	0.14933	0	0	0.1507
Landslide	0.036032	0.00031	0.04286	0.04651	0.12571
Drought	0.002437	0.00033	0	0	0.00276
Tsunami	0	0	0	0	0
Human Hazards	0.045994	0.00298	0.31429	0.5	0.86326
Wildfire	0.004663	0.00055	0	0	0.00521
Severe Storm	0.102162	0.00134	0.18571	0.25581	0.54503
Fog	0.5	0	0.02857	0	0.52857
Lightning	0.002967	2.66E-05	0.08571	0.06977	0.15848
Tornado	0.014413	8.72E-05	0	0	0.0145
Wind	0.004133	2.26E-05	0	0.02326	0.02741
Hail	0.006571	2.71E-05	0	0.01163	0.01823
Heat	0.008902	0	0	0	0.0089



Climate Sensitivity

Each hazard was classified zero or one (0 or 1) on its climate sensitivity, or its connection to current and future weather. If a hazard's root cause is meteorological (floods, hurricanes, heat, hail, etc.) it is climate sensitive and scored with a one (1). If a hazard is geophysical (earthquake, tsunami, etc.) it is not climate sensitive and is scored with a zero (0).

Probability/Consequence

Generally, hazards fall into two (2) specific types in terms of probability and consequence. Low probability/high consequence disasters (earthquake, tsunami) have a generally low frequency of occurrence with a much higher consequence when they do occur. Conversely, high probability/low consequence events occur more frequently, but cause less damage and impact on society when they do. Each hazard event type was appraised on its probability/consequence and scored between Low (.05) and High (1).

Future Consequence

Each hazard included in the assessment has either impacted Puerto Rico in the past or has the potential to cause future impacts. Future consequence scores each hazard on its potential to be an impactful hazard in the future. Future consequence scores range from Low (.05) to High (1) and are derived from a review of Puerto Rico's 2016 SHMP[89]. Hazards identified as "high priority" in the plan were scored high future consequence and hazards not in the plan (heat, tornado, severe storm, etc.) were scored lower on future consequence (.05 or .1).

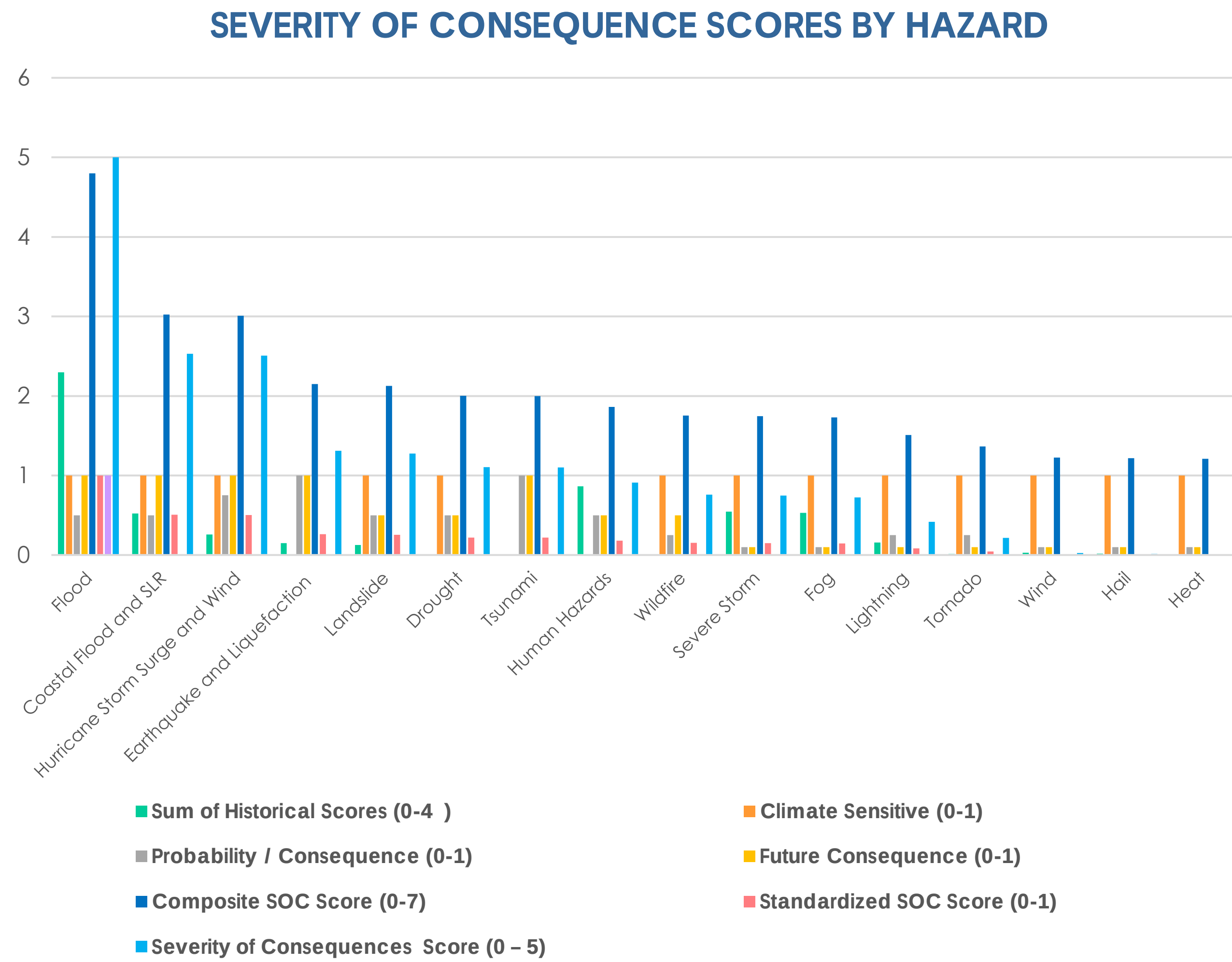
Resulting Severity of Consequences (SOC) score

Applying Severity of Consequences (see equation under Severity of Consequences section in pages prior) to historical consequences, climate sensitivity, probability/consequence, and future consequences result in a standardized value for the severity of consequences (**SOC**) for each hazard analyzed in this assessment. In this case, flooding hazard poses the highest risk and heat hazard poses the lowest risk across Puerto Rico (see table below).

Severity of Consequence Scores by Hazard

Hazard	Sum of Historical Scores (0-4)	Climate Sensitive (0-1)	Probability / Consequence (0-1)	Future Consequence (0-1)	Composite SOC Score (0-7)	Standardized SOC Score (0-1)	Rank	Severity of Consequences Score (0 – 5)
Flood	2.298	1.000	0.500	1.000	4.798	1.000	1	5.000
Coastal Flood and SLR	0.524	1.000	0.500	1.000	3.024	0.506	2	2.529
Hurricane Storm Surge and Wind	0.258	1.000	0.750	1.000	3.008	0.501	3	2.507
Earthquake and Liquefaction	0.151	0.000	1.000	1.000	2.151	0.262	4	1.312
Landslide	0.126	1.000	0.500	0.500	2.126	0.255	5	1.277
Drought	0.003	1.000	0.500	0.500	2.003	0.221	6	1.106
Tsunami	0.000	0.000	1.000	1.000	2.000	0.220	7	1.102
Human Hazards	0.863	0.000	0.500	0.500	1.863	0.182	8	0.912
Wildfire	0.005	1.000	0.250	0.500	1.755	0.152	9	0.761
Severe Storm	0.545	1.000	0.100	0.100	1.745	0.149	10	0.747
Fog	0.529	1.000	0.100	0.100	1.729	0.145	11	0.724
Lightning	0.158	1.000	0.250	0.100	1.508	0.083	12	0.417
Tornado	0.015	1.000	0.250	0.100	1.365	0.043	13	0.217
Wind	0.027	1.000	0.100	0.100	1.227	0.005	14	0.026
Hail	0.018	1.000	0.100	0.100	1.218	0.003	15	0.013
High Temperature	0.009	1.000	0.100	0.100	1.209	0.000	16	0.001

[89] 2016 Puerto Rico Hazard Mitigation Plan. Accessed under file name "Puerto Rico Plan de Mitigación-Aprobado 02/08/2016" at the following website location: https://recovery.pr/en/document-library.



DETERMINED RISK

The risk from hazard for each 0.5-square-mile hex grid was derived from the product of Vulnerability, Hazard, and Severity of Consequence (see Hazard Risk Calculation equation below).

Equation 4: Hazard Risk Calculation

$$RISK_{HAZ_n} = (VUL)(HAZ_n)(CON_{HAZ_n})$$

Risk scores for each hazard were created using this method, and the highest risk hazards (by hex grid) were mapped to identify trends in risk across Puerto Rico (Figure 36).

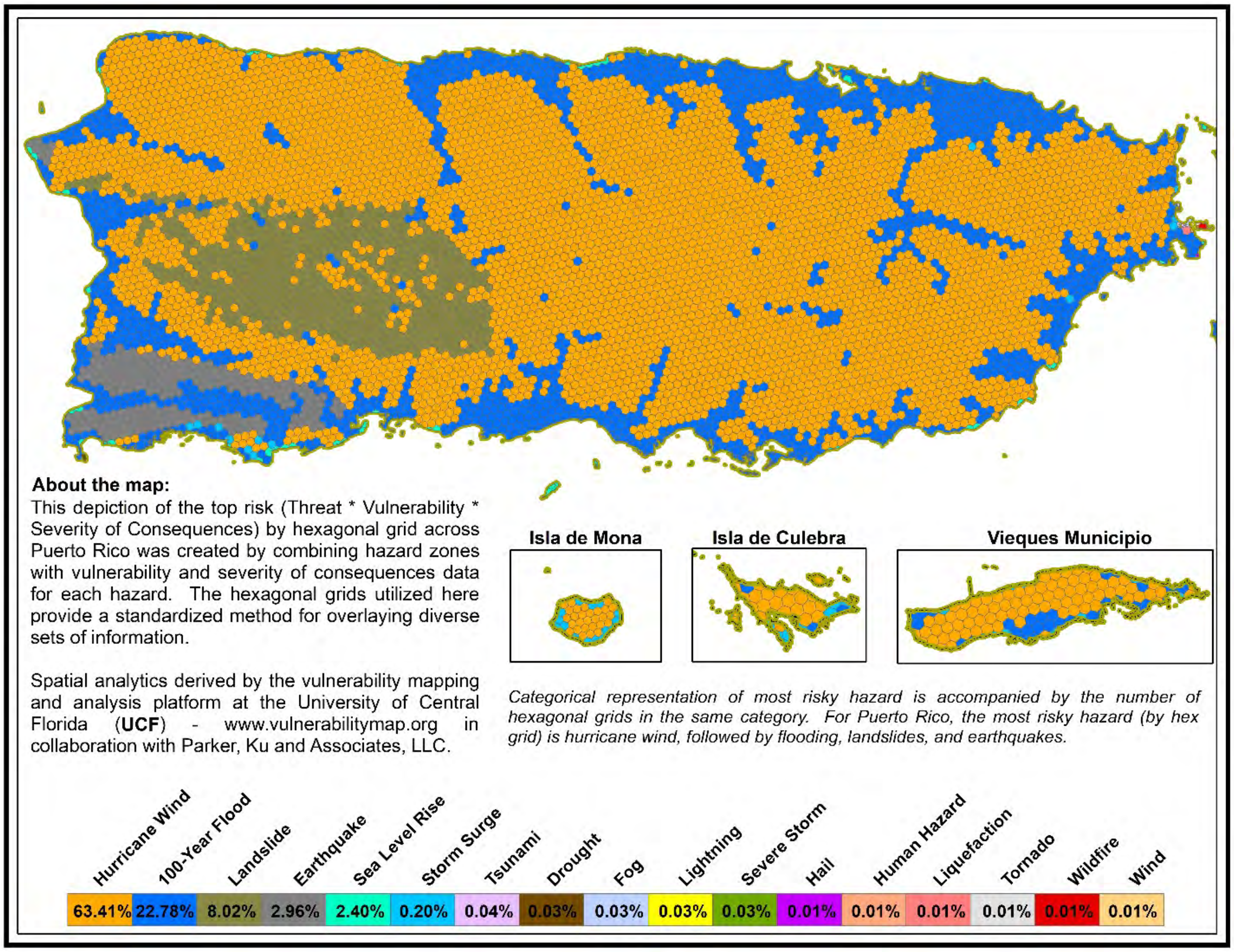


Figure 45: Puerto Rico's Highest Risk Hazards by Hexagonal Grid

Aggregate risk was determined by the sum of risk for each hazard per 0.5-square-mile hex grid (see Total Risk Calculation equation below). The map on the following page shows the aggregate risk in Puerto Rico at the hex grid level.

Equation 5: Total Risk Calculation

$$SUM\ RISK = \sum_{n=1}^{24} RISK_{HAZ_n}$$

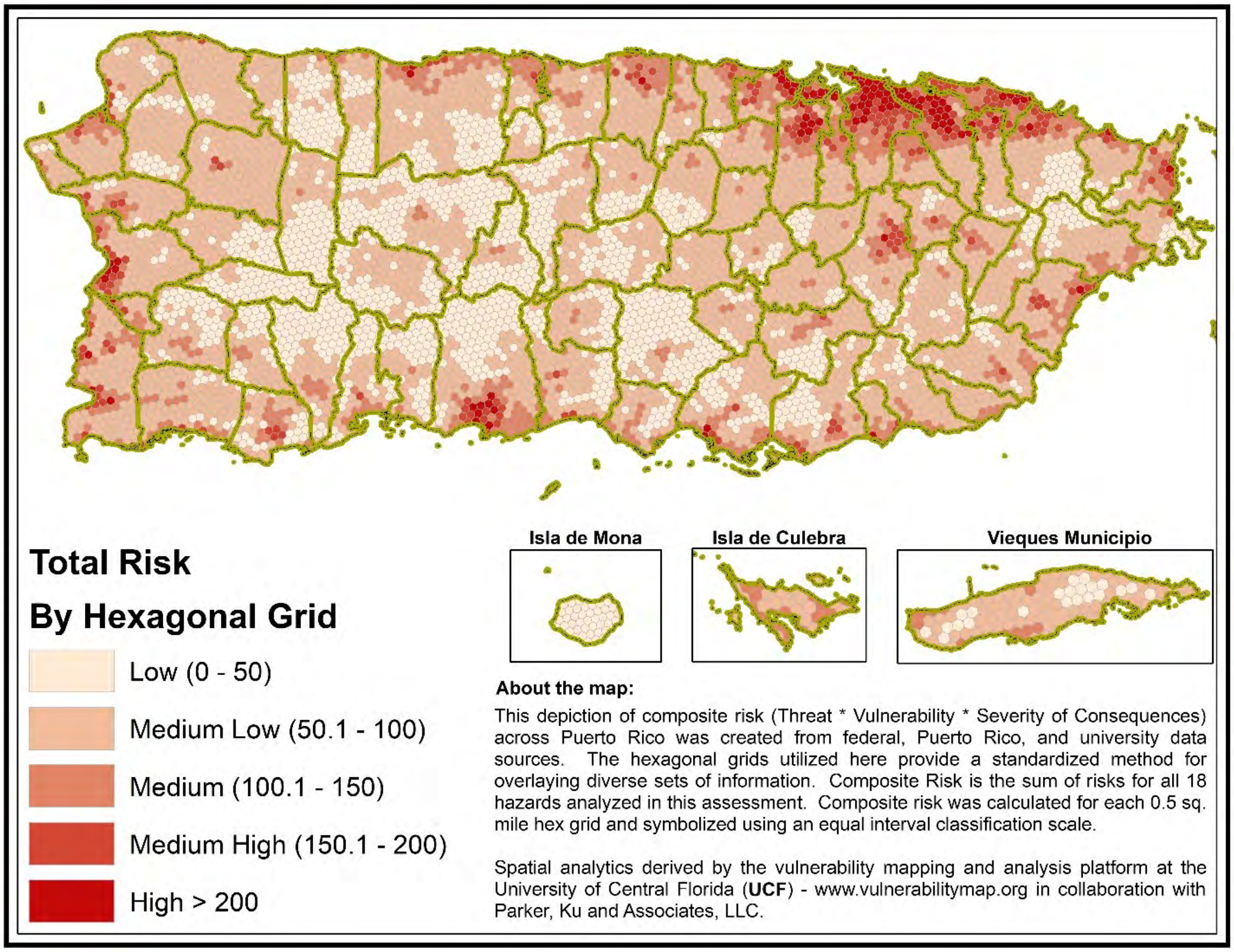


Figure 46: Puerto Rico's Aggregate Risk

Hazards were ranked based on risk at the hex grid level and at the municipality level. To rank hazards based on risk at the municipality level, ESRI ArcGIS Pro was used to perform a union between GIS layers of Puerto Rico Municipalities and a hex grid with the calculated risk described above and noted in the Aggregate Hazard Risk Per Municipality Calculation equation below. The sum of total risk per hazard per municipality is then shown in the map below.

Equation 6: Aggregate Hazard Risk Per Municipality Calculation

$$AGGREGATE\ RISK\ PER\ MUNICIPO\ = SUM\ RISK$$

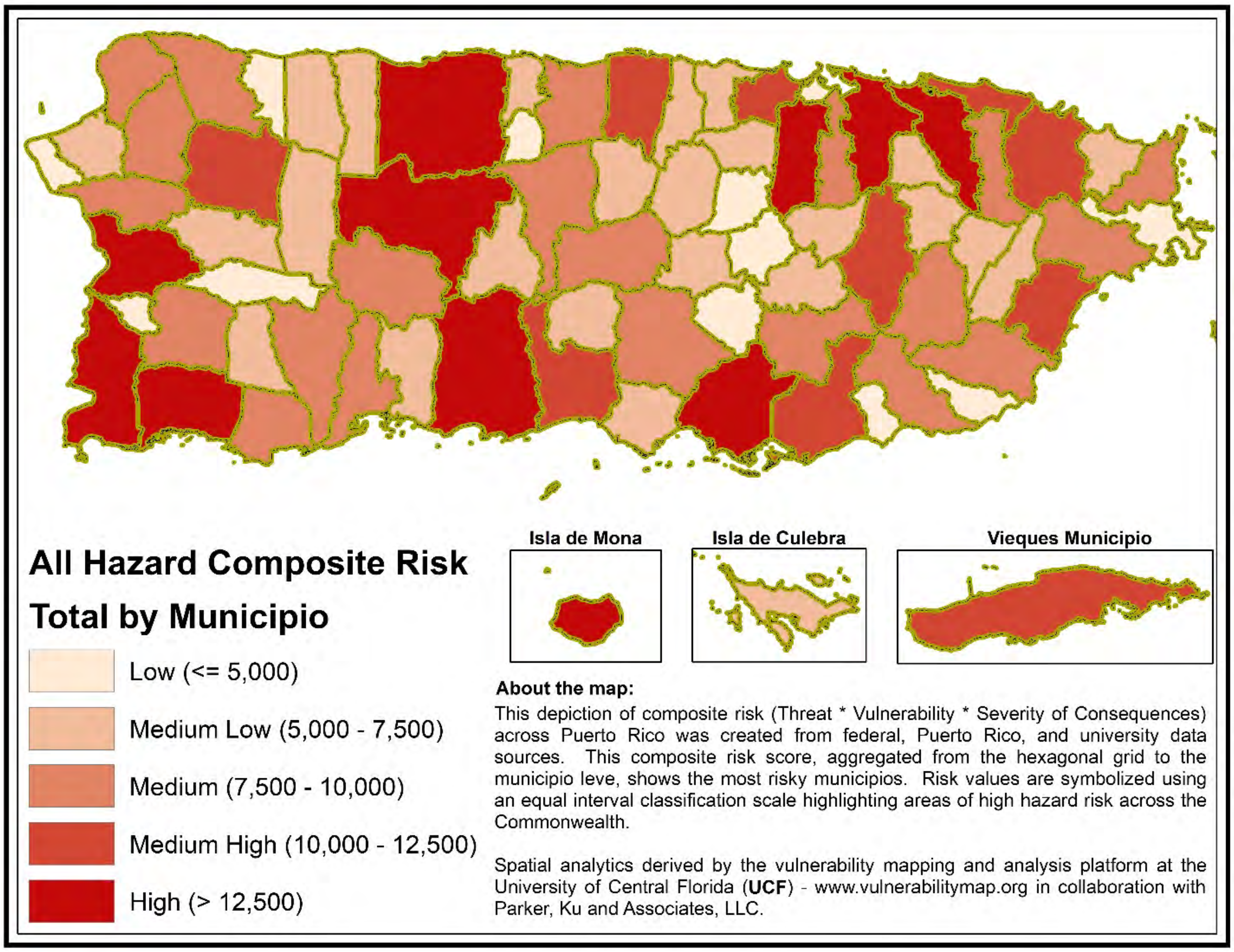


Figure 47: Puerto Rico's Total Risk by Municipality

Total risk was then normalized based on total area of each municipality to provide an area weighted perspective of risks using the Hazard Risk Per Municipality Calculation equation below. The map below the equation displays the area weighted risks for each municipality across Puerto Rico.

Equation 7: Hazard Risk Per Municipality Calculation

$$RISK\ PER\ MUNICIPO = \frac{SUM\ RISK}{AREA\ OF\ MUNICIPIO}$$

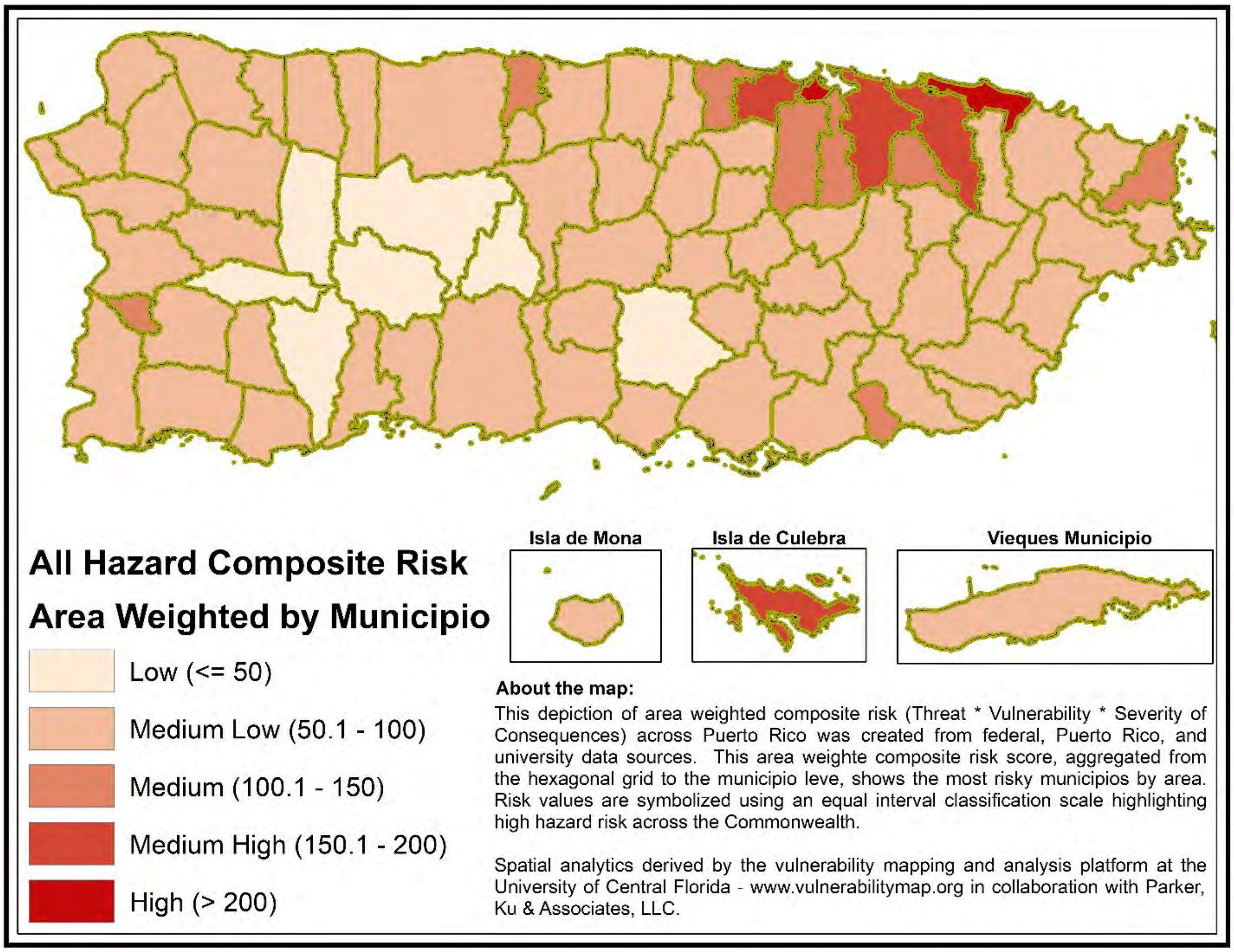


Figure 48: Puerto Rico's Area Weighted Risk by Municipality

Finally, top hazard risks per municipality were selected from the aggregated hazard risk data for each municipality. Mapping the top two (2) hazard risks provides a unique perspective into the variety of hazards impacting Puerto Rico (see map below) and the more robust list of top five (5) hazards per municipality, identifies several priority hazards for Puerto Rico in terms of overall risks (see Top 5 Hazard Risk by Municipality table below the map).

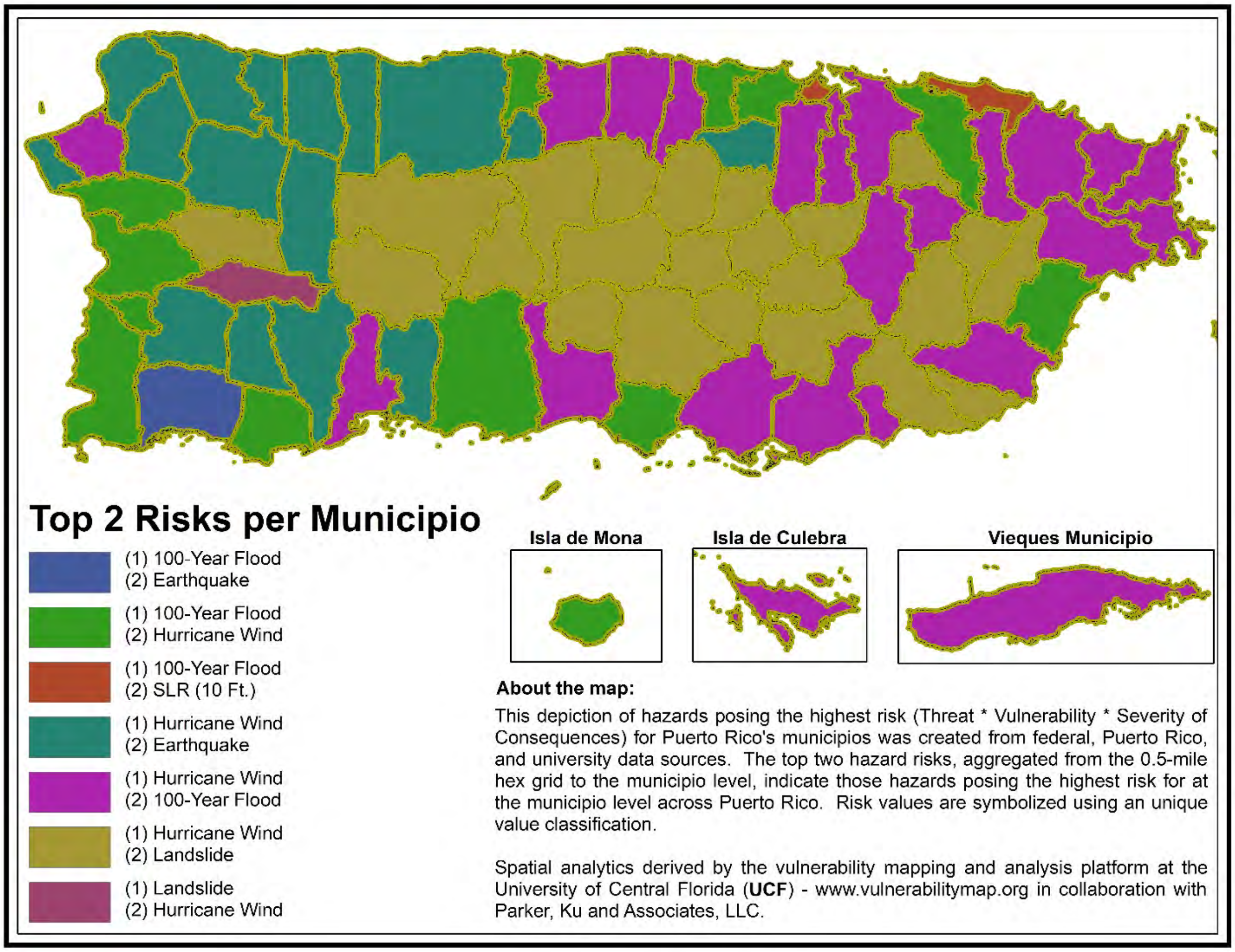


Figure 49: Puerto Rico's Top 2 Hazard Risks by Municipality

Risk Assessment Results at Municipio Level

Top 5 Hazard Risk by Municipality					
Municipality	**Top Risk**	**2nd Highest Risk**	**3rd Highest Risk**	**4th Highest Risk**	**5th Highest Risk**
Adjuntas	Hurricane Wind	Landslide	Earthquake	100-Year Flooding	Lightning
Aguada	Hurricane Wind	100-Year Flooding	Earthquake	Landslide	Liquefaction
Aguadilla	Hurricane Wind	Earthquake	100-Year Flooding	Landslide	Liquefaction
Aguas Buenas	Hurricane Wind	Landslide	Earthquake	Drought	Severe Storm
Aibonito	Hurricane Wind	Landslide	Drought	Earthquake	100-Year Flooding
Añasco	100-Year Flooding	Hurricane Wind	Earthquake	Landslide	Severe Storm
Arecibo	Hurricane Wind	Earthquake	100-Year Flooding	Landslide	Liquefaction
Arroyo	Hurricane Wind	100-Year Flooding	Landslide	Earthquake	Drought
Barceloneta	100-Year Flooding	Hurricane Wind	Earthquake	SLR (10 Feet)	Liquefaction
Barranquitas	Hurricane Wind	Landslide	Earthquake	Drought	Wildfire
Bayamón	Hurricane Wind	100-Year Flooding	Earthquake	Landslide	Liquefaction
Cabo Rojo	100-Year Flooding	Hurricane Wind	Earthquake	Liquefaction	SLR (10 Feet)
Caguas	Hurricane Wind	100-Year Flooding	Landslide	Earthquake	Drought
Camuy	Hurricane Wind	Earthquake	Landslide	Liquefaction	100-Year Flooding
Canóvanas	Hurricane Wind	100-Year Flooding	Landslide	Earthquake	Severe Storm
Carolina	100-Year Flooding	Hurricane Wind	Earthquake	Landslide	SLR (10 Feet)
Cataño	100-Year Flooding	SLR (10 Feet)	Hurricane Wind	Earthquake	Category 5 Storm Surge
Cayey	Hurricane Wind	Landslide	Drought	Earthquake	100-Year Flooding
Ceiba	Hurricane Wind	100-Year Flooding	Landslide	Earthquake	Fog
Ciales	Hurricane Wind	Landslide	Earthquake	Severe Storm	100-Year Flooding
Cidra	Hurricane Wind	Landslide	Drought	Earthquake	100-Year Flooding
Coamo	Hurricane Wind	Landslide	Earthquake	Drought	100-Year Flooding
Comerío	Hurricane Wind	Landslide	Drought	Earthquake	Liquefaction

Top 5 Hazard Risk by Municipality					
Municipality	**Top Risk**	**2nd Highest Risk**	**3rd Highest Risk**	**4th Highest Risk**	**5th Highest Risk**
Corozal	Hurricane Wind	Landslide	Earthquake	Drought	Severe Storm
Culebra	Hurricane Wind	100-Year Flooding	SLR (10 Feet)	Earthquake	Category 5 Storm Surge
Dorado	100-Year Flooding	Hurricane Wind	Earthquake	Liquefaction	SLR (10 Feet)
Fajardo	Hurricane Wind	100-Year Flooding	Earthquake	Landslide	SLR (10 Feet)
Florida	Hurricane Wind	Earthquake	Landslide	Liquefaction	Wildfire
Guánica	100-Year Flooding	Hurricane Wind	Earthquake	SLR (10 Feet)	Landslide
Guayama	Hurricane Wind	100-Year Flooding	Drought	Landslide	Earthquake
Guayanilla	Hurricane Wind	100-Year Flooding	Earthquake	Landslide	Drought
Guaynabo	Hurricane Wind	100-Year Flooding	Landslide	Earthquake	Human Hazard
Gurabo	Hurricane Wind	100-Year Flooding	Landslide	Earthquake	Drought
Hatillo	Hurricane Wind	Earthquake	Landslide	Liquefaction	100-Year Flooding
Hormigueros	100-Year Flooding	Hurricane Wind	Earthquake	Liquefaction	Landslide
Humacao	100-Year Flooding	Hurricane Wind	Landslide	Earthquake	Drought
Isabela	Hurricane Wind	Earthquake	Landslide	100-Year Flooding	Liquefaction
Jayuya	Hurricane Wind	Landslide	Earthquake	Severe Storm	Liquefaction
Juana Díaz	Hurricane Wind	100-Year Flooding	Earthquake	Landslide	Drought
Juncos	Hurricane Wind	Landslide	100-Year Flooding	Earthquake	Drought
Lajas	100-Year Flooding	Earthquake	Hurricane Wind	Landslide	Liquefaction
Lares	Hurricane Wind	Earthquake	Landslide	Lightning	Severe Storm
Las Marías	Hurricane Wind	Landslide	Earthquake	Severe Storm	Lightning
Las Piedras	Hurricane Wind	Landslide	Earthquake	Drought	Severe Storm
Loíza	100-Year Flooding	SLR (10 Feet)	Hurricane Wind	Category 5 Storm Surge	Liquefaction
Luquillo	Hurricane Wind	100-Year Flooding	Landslide	Earthquake	Liquefaction
Manatí	Hurricane Wind	100-Year Flooding	Earthquake	Landslide	Liquefaction

Top 5 Hazard Risk by Municipality					
Municipality	**Top Risk**	**2nd Highest Risk**	**3rd Highest Risk**	**4th Highest Risk**	**5th Highest Risk**
Maricao	Landslide	Hurricane Wind	Earthquake	Severe Storm	Lightning
Maunabo	Hurricane Wind	Landslide	100-Year Flooding	Earthquake	Drought
Mayagüez	100-Year Flooding	Hurricane Wind	Earthquake	Landslide	SLR (10 Feet)
Moca	Hurricane Wind	Earthquake	Landslide	Severe Storm	Liquefaction
Morovis	Hurricane Wind	Landslide	Earthquake	Severe Storm	Liquefaction
Naguabo	Hurricane Wind	100-Year Flooding	Landslide	Earthquake	Liquefaction
Naranjito	Hurricane Wind	Landslide	Earthquake	Drought	100-Year Flooding
Orocovis	Hurricane Wind	Landslide	Earthquake	Drought	Severe Storm
Patillas	Hurricane Wind	Landslide	100-Year Flooding	Earthquake	Drought
Peñuelas	Hurricane Wind	Earthquake	100-Year Flooding	Landslide	Drought
Ponce	100-Year Flooding	Hurricane Wind	Earthquake	Landslide	Drought
Quebradillas	Hurricane Wind	Earthquake	Landslide	100-Year Flooding	Liquefaction
Rincón	Hurricane Wind	Earthquake	Landslide	100-Year Flooding	SLR (10 Feet)
Río Grande	Hurricane Wind	100-Year Flooding	Landslide	Earthquake	SLR (10 Feet)
Sabana Grande	Hurricane Wind	Earthquake	Landslide	Wildfire	Liquefaction
Salinas	Hurricane Wind	100-Year Flooding	Drought	Earthquake	Landslide
San Germán	Hurricane Wind	Earthquake	100-Year Flooding	Landslide	Liquefaction
San Juan	Hurricane Wind	100-Year Flooding	Human Hazard	Earthquake	Landslide
San Lorenzo	Hurricane Wind	Landslide	Earthquake	Drought	Severe Storm
San Sebastián	Hurricane Wind	Earthquake	Landslide	Severe Storm	100-Year Flooding
Santa Isabel	100-Year Flooding	Hurricane Wind	Earthquake	Drought	SLR (10 Feet)
Toa Alta	Hurricane Wind	Earthquake	Landslide	100-Year Flooding	Liquefaction
Toa Baja	100-Year Flooding	Hurricane Wind	SLR (10 Feet)	Earthquake	Liquefaction
Trujillo Alto	Hurricane Wind	Landslide	Earthquake	100-Year Flooding	Drought

Top 5 Hazard Risk by Municipality					
Municipality	**Top Risk**	**2nd Highest Risk**	**3rd Highest Risk**	**4th Highest Risk**	**5th Highest Risk**
Utuado	Hurricane Wind	Landslide	Earthquake	100-Year Flooding	Lightning
Vega Alta	Hurricane Wind	100-Year Flooding	Earthquake	Landslide	Liquefaction
Vega Baja	Hurricane Wind	100-Year Flooding	Earthquake	Landslide	Liquefaction
Vieques	Hurricane Wind	100-Year Flooding	SLR (10 Feet)	Earthquake	Category 5 Storm Surge
Villalba	Hurricane Wind	Landslide	Earthquake	100-Year Flooding	Severe Storm
Yabucoa	Hurricane Wind	100-Year Flooding	Landslide	Earthquake	Drought
Yauco	Hurricane Wind	Earthquake	Landslide	100-Year Flooding	Drought

Public Access to Determined Risk

These risk assessment results are available in the *Puerto Rico Hazards and Risk Dashboard*, a transparent web-based tool available for public use (shown below). The tool allows citizens to view risk analysis data at the Island-wide, municipal, and 0.5-square-mile hex grid level. The dashboard will remain available on the CDBG-MIT website in English and Spanish at https://cdbg-dr.pr.gov/en/cdbg-mit/ and https://cdbg-dr.pr.gov/cdbg-mit/.

Risk per hazard is displayed at the bottom of the dashboard as a dynamic bar chart that updates to display the risk per hazard based on the viewing extent. Specific municipalities can be selected via the drop-down menu at the top right corner of the dashboard. This will automatically adjust the viewing extent and display the total risk score for that municipality – which is the sum of all risks displayed in the bar chart at the bottom – as a score compared to the Island-wide average risk score.

Analysis results per individual 0.5-square-mile hex-grid can also be selected by zooming in to the area. By clicking on the hex grid, users can view a detailed pop up of ranked risks, and risk score for all hazards included in the risk assessment.

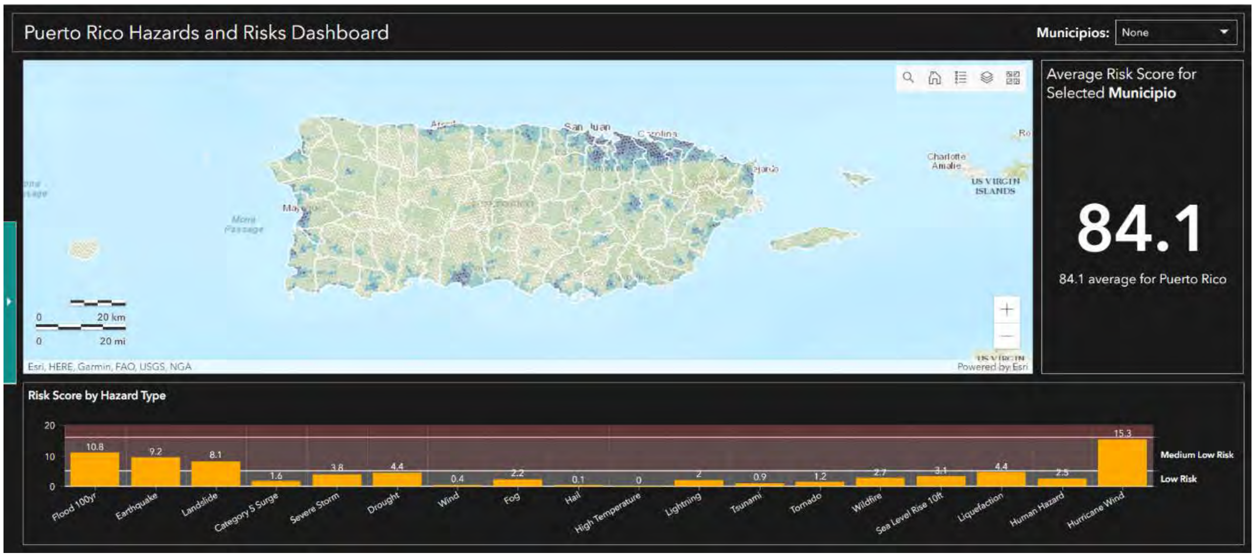


Figure 50. Image of Puerto Rico Hazards and Risks Dashboard

ANALYSIS OF CRITICAL LIFELINES AND INTERDEPENDENCIES

ANALYSIS OF CRITICAL LIFELINES AND INTERDEPENDENCIES

FEMA's community lifelines construct establishes a national standard for disaster response, recovery, and preparedness, including mitigation. The lifelines construct recognizes that communities depend on a network of interdependent systems that involve public and private entities including everything from utilities to hospitals to supermarkets. At any point along the lifeline, a failure can result in cascading failures in other directions and of other lifelines. Lifelines provide a common framework to evaluate the roles and performance of a variety of systems, both public and private, that contribute to consequence management in a disaster event. The lifelines construct is formalized in FEMA's *National Response Framework*, *Fourth Edition*. This resource helps citizens, jurisdictions, agencies, non-governmental organizations (**NGO**), and businesses develop whole community plans that are integrated to protect supply chains, stabilize infrastructure sectors and lifelines, and enable restoration of services in severe incidents.[90]

According to the National Response Framework, recent disasters have illuminated two (2) underlying features of community lifelines that highlight opportunities to strengthen response planning and operations:

- Community lifelines are interdependent and vulnerable to cascading failures; and
- Community lifeline stabilization relies on businesses and infrastructure owners and operators with the expertise and primary responsibility for managing their systems to adopt new doctrine and coordination mechanisms that enable the private sector to play a larger, more comprehensive role in preparedness and response activities.

These concepts are considered in the risk-based needs analysis. Stabilizing community lifelines in catastrophic incidents is vital and requires improved coordination and response structures, reinforced through long-term permanent solutions that mitigate the impact of disaster events.

Interdependent Lifeline Infrastructure

FEMA's lifeline system delineates areas that are essential to human health, safety, and economic security. Each of these lifelines is also interrelated to others through a one-way dependence or two-way interdependence of assets.

[90] National Response Framework, Fourth Edition. October 28, 2019. FEMA. Accessed at: https://www.fema.gov/sites/default/files/2020-04/NRF_FINALApproved_2011028.pdf

PRDOH analyzed these lifeline relationships consistent with the **DHS** definitions for dependence and interdependence, which are described as the following[91]:

- A dependence is a one-way relationship between two (2) assets where the operations of one asset affect the operations of the other.
- An interdependence is a two-way relationship between two (2) assets where the operations of both assets affect each other. An interdependence is effectively a combination of two dependencies.

Figure 51. Illustration of definitions for dependence and interdependence. Source: DHS Infrastructure Interdependency Report, Puerto Rico, 2018

PRDOH recognizes that a mitigation planning process based on community lifelines must consider the dependence and interdependence of the infrastructure resources that support and provide accessibility to those lifelines. Critical lifelines, also referred to as critical infrastructure in this report, are those lifelines and asset infrastructure upon which all other lifelines depend. In Puerto Rico, most lifelines also rely on complex supply chains, which include fuel for emergency generators when the power goes out.

The PRDOH CDBG-MIT Action Plan uses the terms "critical lifelines" and "critical infrastructure" interchangeably, and has adopted the following definition: those systems and assets, whether physical or virtual, so vital to Puerto Rico that the incapacity or destruction of such systems and assets would render other lifelines unusable or inaccessible and would have a debilitating impact on the people of Puerto Rico. Based on extensive analysis of hazards, risks and lifeline assets in Puerto Rico, PRDOH has determined that critical lifelines include sectors within Energy, Transportation, Communications, and Food, Water, and Shelter. For example, access to both food and healthcare depend on the roads being passable; and no lifeline can be operable without energy and communication. According to FEMA, "While [the lifeline concept was] developed to support response planning and operations…[E]fforts to protect lifelines, prevent and mitigate potential impacts to them, and building back stronger and

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[91] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 11, May 2018, http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

smarter during recovery will drive overall resilience."[92] Increasing and improving resilience in Puerto Rico through mitigation efforts depends upon the immediate stabilization of lifelines and fortification of assets.

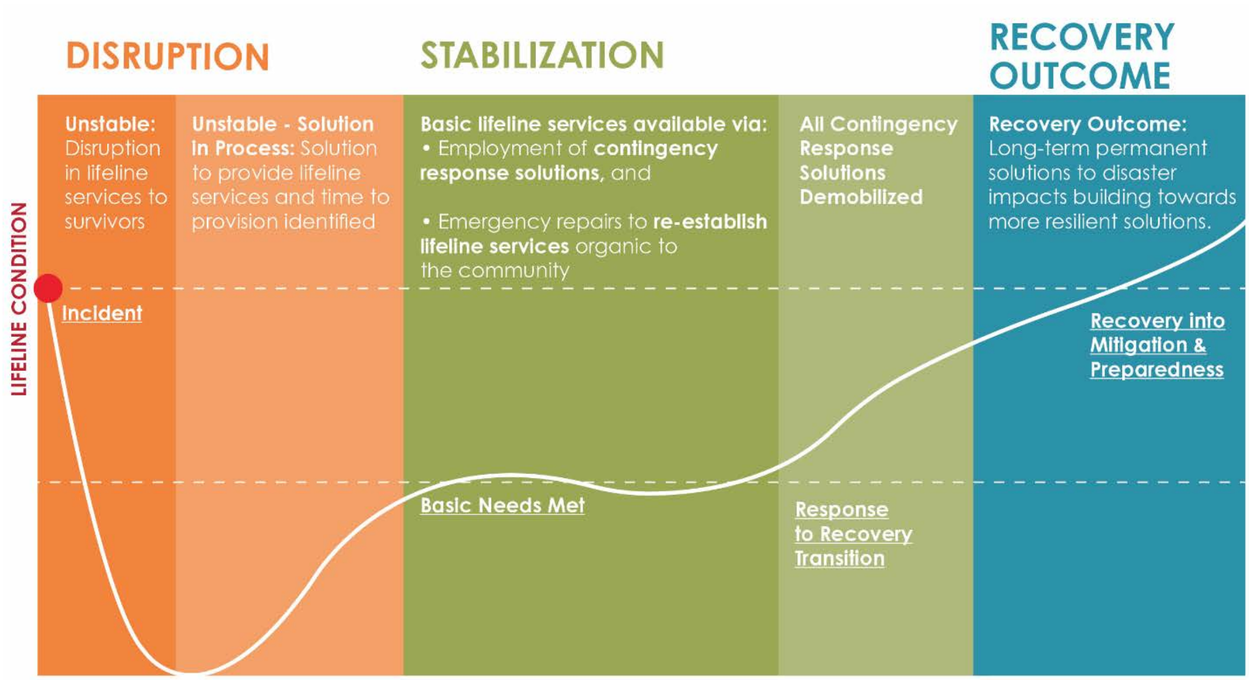

Figure 52. Source: FEMA Incident Stabilization Guide (Operational Draft). FEMA. November 2019.

In May 2018, DHS published the Infrastructure Interdependency Assessment—Puerto Rico[93], a comprehensive analysis of the interdependence of the Island's infrastructure assets after Hurricanes Irma and María. One of the major objectives of the assessment was "characterizing the vital networks of activity for key industries and their dependencies on lifeline infrastructure services and resources." In the report, DHS field research teams found that five (5) sectors provide resources or goods to all other critical infrastructure sectors – synonymous with lifeline sectors: communications, energy, information technology (**IT**)[94], transportation systems, and water and wastewater systems. DHS then went on to identify eight (8) critical infrastructure lifeline subsectors, as the focal points for system characterization in Puerto Rico:

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[92] *What are Community Lifelines.* Community Lifelines. FEMA, https://www.fema.gov/emergency-managers/practitioners/lifelines

[93] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, May 2018, http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

[94] Information Technology is considered a sector within the Communications lifeline.

LIFELINE	LIFELINE SECTOR	LIFELINE SUBSECTOR
Energy Lifeline	→ Energy Sector	→ Electricity Sector → Petroleum and other fuels
Communications Lifeline	→ Communications Sector	→ Communications
Food, Water, and Shelter Lifeline	→ Water/Wastewater Sector	→ Water systems → Wastewater systems
Transportation Lifeline	→ Transportations Systems Sector	→ Maritime transportation → Aviation transportation → Road transportation

The DHS interdependency assessment also included four (4) case studies that came to inform the CDBG-MIT planning process and broader community resilience in Puerto Rico. Together, these case studies highlight several important themes related to critical infrastructure and lifeline resilience in Puerto Rico.[95]:

- **Redundancy**: multiple connections to lifeline infrastructure, preventing the potential consequences of losing service through a single connection.
- **Alternatives**: a diverse set of infrastructure types and locations that reduces the danger of overdependence on infrastructure assets that could become single points of failure during emergencies.
- **Independence**: local control and management of lifeline assets and infrastructure that can reduce the possibility of systemic failure, which has proven to be a significant concern to communities across the Island.
- **Coordination**: collaboration between communities, industries, governmental entities and utilities that proposes changes to critical infrastructure, which would yield more successful outcomes and be more likely to create solutions that meet the needs of communities.
- **Confidence**: operational reliability and predictable costs associated with lifeline infrastructure can increase business confidence, which is crucial to a sustainable economic recovery.

The final citation from the DHS interdependency assessment, perhaps most appropriately and succinctly states the reason consideration of its findings are essential to the CDBG-MIT Action Plan:

[95] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 4, May 2018, http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

Identifying and assessing the cumulative supplies and demands of critical resources and services to inform long-term planning will ultimately support infrastructure resilience, economic recovery, and the revitalization of communities across Puerto Rico.[96]

Critical and Secondary Lifelines

Lifelines are the infrastructure-based network that assures a community's social, economic, and environmental needs are met, and provides a means to recover from hazard events. Strengthening and stabilizing lifelines will enhance social, ecological and technologically-based resilience in Puerto Rico, reducing long-term risk to life and property by lessening the impact of future disasters.

The Food, Water, and Shelter lifeline is essential to human survival. Energy, Communications, and Transportation are considered critical because the other lifelines depend on them for basic functioning. Without the stability of these critical infrastructure assets, Puerto Rico will suffer cascading failures in future events; however, the support of these lifelines through mitigation can be transformative for Puerto Rico's long-term resilience goals and prevent failures in future events.

In addition to the critical lifelines described, PRDOH also recognized secondary lifelines. These secondary lifelines, namely Safety and Security, Health and Medical, and Hazardous Materials Management, have the potential to mitigate immense public health and safety concerns during and after a disaster event. This is especially true where critical infrastructure such as energy, transportation, communication or others has failed. Strategic mitigation will therefore necessarily stabilize and strengthen both critical and secondary lifelines.

Transportation Lifeline Analysis

The Transportation lifeline supports critical supply chain routes for circulation of people, goods, and lifesaving emergency services throughout the Island. Stability of the Transportation lifeline is critical for supply line continuity in everyday life and paramount in disaster events. Without accessible routes, disruption in the supply chain creates scarcity of food, fuel, and medical supplies. Disruption to ingress/egress routes hamper first responder and citizen mobility, especially for a population that relies heavily on personal vehicles for transportation. Currently, seventy-six-point eight percent (76.8%) of the population drives a personal vehicle, twelve-point two percent (12.2%) ride as passengers in personal vehicles, and around seven-point eight percent (7.8%) of the population relies on scant public transportation services.[97]

The Transportation lifeline comprises road networks, bridges, public transit, airports and seaports, and pipelines. The goal of transportation system mitigation is to ensure the

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[96]. *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 192, May 2018, http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

[97] 2045 Puerto Rico Long Range Multimodal Transportation Plan, Puerto Rico Highways and Transportation Authority (PRHTA), Page 63, December 2018. Accessed at: http://lrtp.steergroup.com.co/wp-content/uploads/2018/12/PR-Island-wide_FINAL.pdf

continuous functioning of the transportation system, preventing the occurrence of conditions that would inhibit the movement of people and supplies.

Road networks and highway systems allow for the movement of people and supplies prior to, during, and after a disaster event. Evacuations and the movement of emergency response teams are critical response-related functions, while transportation of relief supplies post-event is a necessary component of emergency response and stabilization. The highway system includes main corridors, road segments, signal and traffic control centers, signs, and other roadside assets.

Bridges, including culverts, storm sewers, and tunnels, are also key transportation infrastructure. There are approximately 1,632 highway bridges and 312 toll road bridges that fall under the purview of the Puerto Rico Highway Transportation Authority, and Municipalities maintain authority over approximately 374 bridges. Damage reports following Hurricane María showed that 388, or twenty-two percent (22%) of all bridges in Puerto Rico were damaged. Importantly, the municipality of Quebradillas experienced damage to two-thirds (2/3) of their bridges.[98]

The public transit components of the Transportation lifeline include: light rail system in the San Juan metropolitan area (**Tren Urbano**), Metropolitan Transit Authority (**MTA**), buses/trolleys, public cars and ferry boats. These services provide Puerto Ricans access to employment, education, medical services and other necessities of daily life. Two percent (2%) of the public depends on these services. Puerto Rico depends on five (5) ferries located in Ceiba, Fajardo, Culebra, Vieques and Cataño to provide public maritime transportation for residents of Puerto Rico and transportation of goods between the islands that comprise Puerto Rico.

Airports and seaports are also essential components of the Transportation lifeline. There are three (3) major airports and forty-seven (47) minor airports and heliports that are used for the inflow of emergency personnel during states of emergency, for the movement of essential services personnel and freight, as well as the evacuation of people and hospital patient transfer flights. There is a total of twelve (12) seaports, six (6) of which are main seaports including: San Juan Bay, Arecibo, Yabucoa, Guayama, Guánica and Guayanilla. These ports play a vital role in delivery of goods and are used by container vessels and tankers.

Pipelines provide an alternative to the highway system as a means of transport of natural gas and other fuels between gas terminals at ports to electricity generation plants, as well as business such as the hotel industry and homes and gasoline through retail distribution systems.

[98] 2045 Puerto Rico Long Range Multimodal Transportation Plan, Puerto Rico Highways and Transportation Authority (PRHTA), Page 95, December 2018. Accessed at: http://lrtp.steergroup.com.co/wp-content/uploads/2018/12/PR-Island-wide_FINAL.pdf

Maritime Transportation Interdependencies

As an island, Puerto Rico has a disproportionate reliance on maritime systems involving waterways and ports, when compared to other transportation systems subsectors. There is a total of eleven (11) seaports operated by the Puerto Rico Ports Authority (**PRPA**) under Puerto Rico's Department of Transportation and Public Works (**DTPW**), and the Port of Ponce is operated by the Port of the Americas Authority.

Shipping and supporting functions (e.g., fuel, electric power, coastal highways, and trucking) are required for trade, commerce, and commodities to maintain daily life, economic activity, and government services in Puerto Rico.[99] This fact was borne out in the aftermath of Hurricanes Irma and María. FEMA encountered significant challenges in coordinating and moving resources due to the distance between Puerto Rico and the US mainland, coupled with challenging on-the-ground conditions.[100]

In 2016, three (3) major seaports in Puerto Rico, the Port of San Juan, Port of Ponce, and Port of Fajardo, together accounted for approximately ninety-nine percent (99%) of the total value and weight of all foreign throughputs. A significant majority of this throughput transits through the Port of San Juan.[101]

The Electricity, Fuels (Petroleum, Natural Gas, and Coal), and Maritime Transportation subsectors are highly interdependent in Puerto Rico, representing a critical cross-sector nexus. Nearly all electricity generated in Puerto Rico comes from fossil fuel sources (e.g., ninety-six percent (96%) of all projected electricity generation in 2018). All this fuel is imported to Puerto Rico through maritime ports, which themselves require electricity for intermodal operations.[102]

Puerto Rico's dependence on maritime shipping means that a disruption to the lifeline sector can have a rippling effect on other critical infrastructure, including the Energy, Agriculture and Food, Critical Manufacturing, Chemical, Commercial Facilities, and Healthcare and Public Health sectors. Therefore, the resilience of the Island's ports—in particular the Port of San Juan—is essential to the resilience of Puerto Rico.[103]

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[99] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 131, May 2018, http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

[100] *2017 Hurricane Season FEMA After-Action Report*, FEMA. Pages 25-26, July 12, 2018. Accessed at: https://www.fema.gov/media-library-data/1531743865541-d16794d43d3082544435e1471da07880/2017FEMAHurricaneAAR.pdf

[101] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 134, May 2018, http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

[102] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 134, May 2018, http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

[103] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 143, May 2018, http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

The Port of San Juan was identified by the DHS Interdependency Assessment as a single point of failure for the delivery of nearly every product sent or received by Puerto Rico.[104] However, Port of the Americas Authority plans are currently underway to develop the Port of Ponce to serve as a transshipment hub to increase resiliency and redundancy in the transportation lifeline and enhance circulation routes.

Road Transportation Interdependencies

Puerto Rico depends heavily on its road transportation system for delivery of goods and services; there is no alternative ground transportation system available to move goods. A disruption to the road transportation network can have rippling effects on other infrastructure sectors. FEMA reported that, following the 2017 hurricanes, major modes of transportation were closed, and debris blocked extensive road networks across the three (3) inhabited Islands of Puerto Rico. Reopening these road networks required an in-depth assessment and clearance effort.[105]

The *2045 Long-range Transportation* Plan for San Juan reported that road infrastructure supporting the Port of San Juan and Luiz Muñoz Marín International Airport was inadequate. Limits on vehicular access to these transportation hubs constrain the flow of goods during non-emergency situations, delaying shipments. All sectors of the Puerto Rico economy rely on the highway system because cargo in Puerto Rico is moved entirely by truck. For example, nearly all food imported into Puerto Rico arrives at the Port of San Juan and relies on road transportation for delivery to the consumer.[106] Consequently, ensuring the reliability of the road transportation network is essential to building a resilient Puerto Rico that meets the needs of its individual citizens, as well as the needs of the business community.[107]

Aviation Transportation Interdependencies

Puerto Rico's dependence on the Aviation subsector can cause a rippling effect on other infrastructure sectors, including the Agriculture and Food, Critical Manufacturing, and Commercial Facilities (i.e., tourism) sectors. In the aftermath of Hurricane Maria, FEMA encountered significant challenges in coordinating and moving additional resources due to Puerto Rico's geographic distance from the U.S. mainland and six (6) day average transit time for resources moved by barge to the Caribbean. FEMA's resulting sustained air mission of food and water delivery was the longest in its history,

[104] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 187, May 2018, http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

[105] *2017 Hurricane Season FEMA After-Action Report*, FEMA, Pages 28-29, July 12, 2018. Accessed at: https://www.fema.gov/media-library-data/1531743865541-d16794d43d3082544435e1471da07880/2017FEMAHurricaneAAR.pdf

[106] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page. 170. May 2018, http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

[107] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 176, May 2018. http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

illustrating the critical importance of the aviation sector to Puerto Rico's resilience. [108] Therefore, the resilience of the Island's airports—in particular the two (2) largest, Luis Muñoz Marín and Rafael Hernández International Airports—are important to the resilience of Puerto Rico as a whole.[109]

Puerto Rico has ten (10) airports included in the National Plan of Integrated Airport Systems (NPIAS) for the period of 2017-2021. This National Plan identifies existing and proposed airports that are significant to national air transportation and are eligible to receive federal grants under the Airport Improvement Program (AIP). [110]

The Luis Muñoz Marín International Airport and the Rafael Hernández Airport are the highest-ranking airports regarding cargo volume, according to AeroWeb Forecast International's Aerospace Portal. Both were nationally ranked thirty-fourth (34th) and forty-ninth (49th), respectively in 2016. This relatively high ranking is an indicator of the key role both airports play as cargo terminals for the Island.[111]

Operations at airports depend on services and resources for supporting regional lifeline infrastructure. Aviation facilities and systems depend on electric power, fuel, communication services, financial services, IT, water, and wastewater.[112]

Transportation Lifeline Infrastructure Risk Analysis

Based on the results of the PRDOH Risk Assessment, the map below displays the overlay of Transportation lifeline infrastructure, including road networks, bridges, airports and seaports, and pipelines, along with the high-risk areas of the three (3) inhabited islands of Puerto Rico. The determination of risk is based on the composite risk scores which range from: Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); and High (200 or more).

Approximately twenty-five percent (25%) of the road system infrastructure is in a High, Medium High, or Medium risk area. Comparatively, municipal roads are exposed to the highest risk due to location. Approximately eighty-seven percent (87%) of the municipal transportation infrastructure is in one (1) of the three (3) medium to high risk areas with twenty-six percent (26%) in a high risk area. Both the San Juan and the Ponce ports are

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[108] *2017 Hurricane Season FEMA After-Action Report*, FEMA, pg 41 July 12, 2018. Accessed at: https://www.fema.gov/media-library-data/1531743865541-d16794d43d3082544435e1471da07880/2017FEMAHurricaneAAR.pdf

[109] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 157, May 2018. http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

[110]. 2045 Puerto Rico Long Range Multimodal Transportation Plan, Puerto Rico Highways and Transportation Authority (PRHTA), Page 141, December 2018. Accessed at: http://lrtp.steergroup.com.co/wp-content/uploads/2018/12/PR-Island-wide_FINAL.pdf

[111]. 2045 Puerto Rico Long Range Multimodal Transportation Plan, Puerto Rico Highways and Transportation Authority (PRHTA), Page 146, December 2018. Accessed at: http://lrtp.steergroup.com.co/wp-content/uploads/2018/12/PR-Island-wide_FINAL.pdf

[112]. *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 157, May 2018. http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

in high-risk areas. Fifty-six percent (56%) of the aerial transportation facilities are in one (1) of the three (3) high-risk areas.

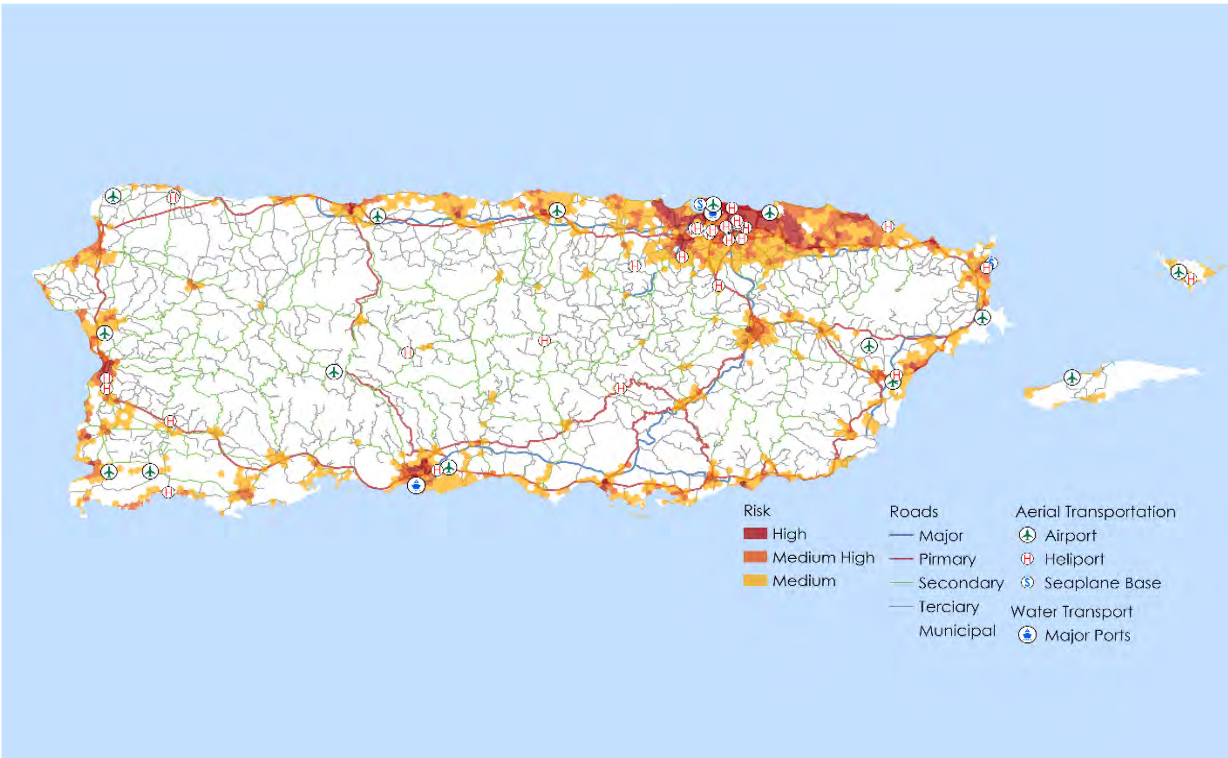

Figure 53. Transportation Facilities and Proximity to Risk Areas Classified as High, Medium High, or Medium

Road Segments in Risk Areas Classified as: High, Medium High, or Medium[113]			
Class	Risk	Road Section Length in Risk Area (Miles)	Percentage of Road Segments in Risk Area
Major	HIGH	10.36	5.51%
	MEDIUM HIGH	10.66	5.67%
	MEDIUM	43.51	23.16%
	Total	**64.52**	**34.34%**
Municipal	**HIGH**	**57.43**	**26.26%**
	MEDIUM HIGH	62.19	28.44%
	MEDIUM	71.71	32.79%
	Total	**191.34**	**87.49%**
Primary	HIGH	60.35	10.98%
	MEDIUM HIGH	75.84	13.79%
	MEDIUM	144.40	26.26%
	Total	**280.59**	**51.04%**

[113] Composite risk scores range from Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); High (200 or more)

Road Segments in Risk Areas Classified as: High, Medium High, or Medium [113]			
Class	Risk	Road Section Length in Risk Area (Miles)	Percentage of Road Segments in Risk Area
Secondary	HIGH	27.39	2.13%
	MEDIUM HIGH	67.81	5.28%
	MEDIUM	149.57	11.64%
	Total	**244.78**	**19.06%**
Tertiary	HIGH	22.60	0.89%
	MEDIUM HIGH	94.34	3.73%
	MEDIUM	289.05	11.43%
	Total	**405.99**	**16.05%**
Grand Total		**1,187.21**	**24.89%**

Transportation Facilities in Risk Areas Classified as: High, Medium High, or Medium [114]			
Transportation Facility Type	Risk	Facilities	Percent of Facilities in Risk Area
Aerial Transportation	HIGH	9	
	MEDIUM HIGH	8	
	MEDIUM	10	
	Total	**27**	**56.25%**
Major Ports*	HIGH	2	
	Total	**2**	**100.00%**
Minor Ports and Docks	HIGH	15	
	MEDIUM HIGH	20	
	MEDIUM	10	
	Total	**45**	**23.08%**
Grand Total		**74**	**37.95%**
**GIS data locates major ports outside of Puerto Rico jurisdictional area considered in the risk assessment. Major ports are assumed high risk based on proximity and location to other high risk areas.*			

[114] Composite risk scores range from Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); High (200 or more)

Energy Lifeline Analysis

Puerto Rico's Energy System

Puerto Rico's power system is a vertically integrated system—meaning that power is generated by companies and transmitted to customers via transmission and distribution lines. The electrical system is run by the Puerto Rico Electric Power Authority (**PREPA**) which serves approximately 1.5 million customers, representing close to $3.45 billion in total annual revenue.

The power system includes:

- 2,748 miles of transmission lines
- 31,485 miles of distribution lines
- 334 substations
- Six (6) generation sites that operate on fossil fuels
- Seven (7) hydroelectric generation sites, owned and operated by PREPA
- Two (2) privately owned co-generation plants that operate on petroleum and natural gas
- Two (2) privately owned windfarms
- Five (5) solar farms.[115]

PREPA generates two-thirds (2/3) of the Island's power and purchases the rest. Energy demand has decreased from a peak of 3,685 megawatts (**MW**) in fiscal year 2006 to 3,159 MW in fiscal year 2014, and 3,060 MW by August 2017, which shows a clear tendency towards shrinking energy demand. Nonetheless, the Authority has a generation capacity of 5,839 MW which includes the 961 MW provided by the EcoEléctrica Power Plant and AES through a twenty (20)-year power purchase agreement.

Energy infrastructure is heavily dependent on fossil fuels and primary backup systems in Puerto Rico, which include fossil-fuel-dependent generators. For the fiscal year 2019, petroleum fueled forty percent (40%) of the Island's total electricity generation, and natural gas thirty-nine percent (39%). Coal continued to fuel eighteen percent (18%) of generation, while renewables supplied two-point three percent (2.3%)..[116]

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[115] Build Back Better: Puerto Rico, Governor of Puerto Rico, Page 18, November 2017. Accessed at: https://fonteva-customer-media.s3.amazonaws.com/00Do0000000Yi66EAC/moiTMBGO_Build_Back_Better_PR_ToCongress_Nov17.pdf

[116] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. *Puerto Rico - Territory Energy Profile Analysis - U.S. Energy Information Administration (EIA)*, 21 Nov. 2019, www.eia.gov/state/analysis.php?sid=RQ

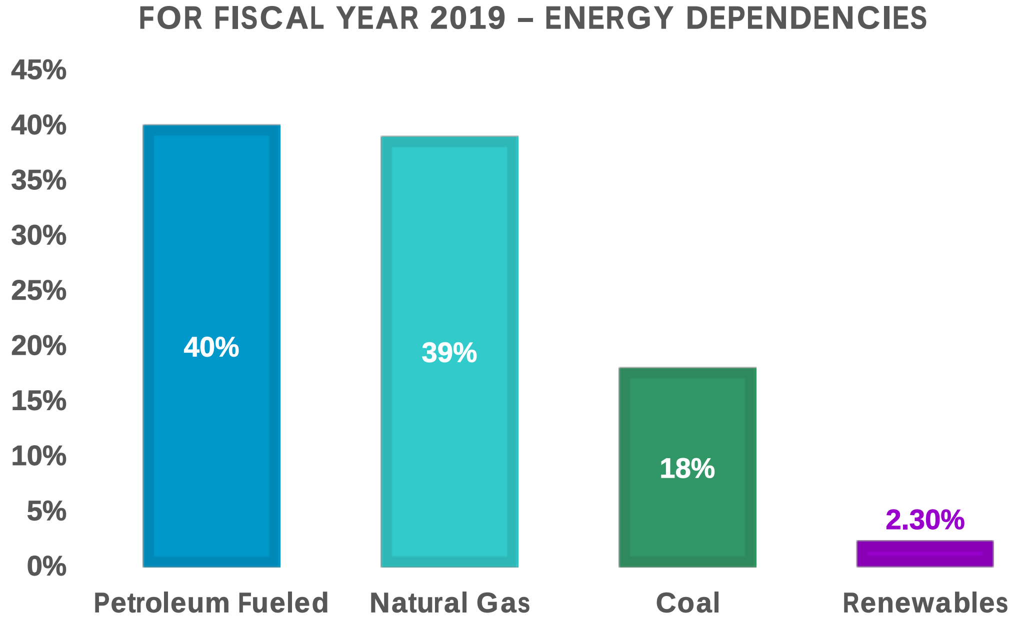

Figure 54. Percent of fossil fuels and renewables that source energy generation for PREPA utilities

Renewable Energy Assets

Prior to the hurricanes, seven (7) solar farms with a total of 147.1 MW, two (2) wind farms with a total of 121 MW, and two (2) landfill gas facilities with a total of 4.8 MW had been constructed and were in operation, for a total of 272.9 MW, or two-point three percent (2.3%) of all energy generated.

Most renewable generating facilities survived Hurricane María with modest amounts of damage and were able to fully re-connect to the grid in early 2018[117] . However, a solar energy farm at Humacao and a wind farm at Naguabo, both on Puerto Rico's east coast where the eye of the storm came ashore, were badly damaged. During the recovery from Hurricane María, Puerto Rico experienced a growth in solar power. As many as 12,000 Puerto Ricans had installed solar power and formed micro-grids prior to Hurricanes Irma and María and at least 10,000 more in the year following.[118] The US Energy Information Administration (**EIA**) reported that for 2018, one-fourth (0.25) of Puerto Rico's annual solar generation came from distributed solar panels on homes and businesses[119]. Puerto Rico has 127 MW of utility-scale solar photovoltaic generating capacity and eighty-eight (88) MW of distributed capacity.

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[117] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. *Puerto Rico - Territory Energy Profile Analysis - U.S. Energy Information Administration (EIA)*, 21 Nov. 2019, www.eia.gov/state/analysis.php?sid=RQ

[118] Kern, Rebecca. "Rooftop Solar Nearly Doubles in Puerto Rico One Year after Maria." ***Bloomberg Law***, Bloomberg, 20 Sept. 2018. Accessed at: https://news.bloomberglaw.com/environment-and-energy/rooftop-solar-nearly-doubles-in-puerto-rico-one-year-after-maria

[119] Deng, Simeng, et. al. Evaluating Viability of Community Solar Microgrids for Resilience in Puerto Rico, Pages 19-21, 2019, Accessed at: https://dukespace.lib.duke.edu/dspace/bitstream/handle/10161/18460/EVALUATING%20VIABILITY%20OF%20COMMUNITY%20SOLAR%20MICROGRIDS%20FOR%20RESILIENCE%20IN%20PUERTO%20RICO.pdf?sequence=2&isAllowed=y

Some communities have formed distributed renewable power micro-grids. In a distributed power system, a community of businesses, for example, would each produce power through rooftop solar. When they have generated more power than they need, the excess power goes to shared energy storage. A virtual grid or smart control system routes power to where it is needed in the community. In some communities, these distributed power micro-grids can connect to and disconnect from the larger grid to share excess power and switch to grid power when necessary. If the main grid goes down, the community grid disconnects, and their power is protected.

In August 2018, the Toro Negro community located in Ciales, formed a non-profit organization named Comunidad Solar Toro Negro to manage and operate their microgrid consisting of twenty (20) solar photovoltaic (**PV**) rooftop plus storage system powering twenty-eight (28) homes. This organization also plans to install an additional solar PV system on their community center.

The Salinas community El Coquí created the group Junta Comunitaria del Poblado Coquí and currently works for the sustainability of the coastline in collaboration with Eco Desarrollo de Bahía de Jobos (**IDEBAJO**), a non-profit organization that integrates community organizations, fishermen associations, and the Environmental Dialogue Committee.[120] The community installed a solar PV system on the community center and was planning to install PV systems on forty (40) neighboring residences that would function as emergency help centers for other residents.[121].

The island of Vieques, home to an estimated 9,000 people, has thirty (30) kilowatts (**kW**) of solar and storage powering the wastewater treatment of the island.[122] One study from Duke University provides examples of bottom-up partnerships between communities, non-profit organizations, project developers and technology companies that have emerged in Puerto Rico.

> "The organizations Para la Naturaleza and Resilient Power Puerto Rico are collaborating for The Community Solar Energy Initiative (**CSEI**), powering community centers with solar PV systems and storage. Currently, there are twenty eight (28) community centers running on solar PV and there is secure funding for another thirty eight (38) systems (Para La Naturaleza-Resilient Power Puerto Rico 2018). Finally, Puerto Rico Community Foundation (**PRCF**) plans to expand solar communities in the island to seventy eight (78) community solar microgrids, two (2) of which have secured funding and are currently in the pipeline (FCPR 2018)."

[120] Deng, Simeng, et. al. Evaluating Viability of Community Solar Microgrids for Resilience in Puerto Rico, Pages 19-21, 2019, Accessed at: https://dukespace.lib.duke.edu/dspace/bitstream/handle/10161/18460/EVALUATING%20VIABILITY%20OF%20COMMUNITY%20SOLAR%20MICROGRIDS%20FOR%20RESILIENCE%20IN%20PUERTO%20RICO.pdf?sequence=2&isAllowed=y

[121] El Coquí Avanza hacia la Independencia Energética, Periódico la Perla. September 12, 2018. Accessed at: https://www.periodicolaperla.com/el-coqui-tambien-avanza-hacia-la-independencia-energetica/

[122] Two Puerto Rican Islands Can Test the Future of Microgrids, Bloomberg Environment. May 21, 2018. Accessed at: https://www.bna.com/two-puerto-rican-n57982092737/

A public-private partnership, the Puerto Rican Solar Business Accelerator, is creating programs to expand the proliferation of solar energy, provide on-the-job training for solar installers in PR, expand financing and more.[123]

Other microgrids have been recommended for critical infrastructure such as hospitals, emergency shelters, and wastewater treatment facilities. In the *Build Back Better* report, the cost of some of these microgrids is estimated:

Facility Type		Number of Sites in Puerto Rico	Technology Required	Estimated Cost Per Site	Targeted Microgrid Deployments	Total CAPEX ($ Millions)
Critical Infrastructure	**Hospitals**	58+	PV, BESS, CHP, RICE	$19 million	26	$496
Critical Infrastructure	**Police Stations**	Approx. 100	PV, BESS, RICE	$240,000	20	$5
Critical Infrastructure	**Fire Stations**	84	PV, BESS, RICE	$240,000	20	$5
Critical Infrastructure	**Emergency Shelters**	452	PV, BESS, RICE	$4.6 million	75	$345
Critical Infrastructure	**Wastewater Treatment Facilities**	50	PV, BESS, RICE	$3.6 million	5	$18
Critical Infrastructure	**Drinking Water Treatment Facilities**	Approx. 100	PV, BESS, RICE	$2.4 million	10	$24
Remote Communities		Multiple	PV, BESS, RICE	$38.1 million	3	$114
TOTAL					**159**	**$1,007**
Source: *New York Power Authority Build Back Better: Reimagining and Strengthening the Power Grid of Puerto Rico, December 2017*						

While PREPA anticipates a future incorporating renewables, its proposed debt restructuring plan includes charging a fee to customers who supply their own power which would increase the cost of individual power generation. However, the cost of installing these renewable energy technologies could be less than rebuilding the vertical grid with fuel rates a fraction of the cost per kilowatt hour than liquefied natural gas (LNG).

Energy System Vulnerabilities

The electric power generation system is approximately thirty (30) years older[124] than the electric power industry average in the US and has been poorly maintained because of budget constraints.

PREPA's largest and most critical generating facilities—Aguirre and Costa Sur, which create roughly seventy percent (70%) of the Island's energy—are located in the south while sixty-five to seventy percent (65-70%) of the system's energy demand is in the north, in and around the city of San Juan where most of the Island's industry and

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[123] Puerto Rican Solar Business Accelerator, The Solar Foundation. Accessed at: https://www.thesolarfoundation.org/prsba/

[124] Microreactors for Resilient Power in Puerto Rico. Homeland Security News Wire, June 17, 2020. Accessed at: http://www.homelandsecuritynewswire.com/dr20200617-microreactors-for-resilient-power-in-puerto-rico#:~:text=The%20U.S.%20territory%20of%20Puerto,than%20mainland%20U.S.%20power%20plants

population is located. Electrical power must traverse the Island's mountainous terrain from south to north using high voltage overhead transmission lines that are vulnerable to hurricane force winds. Consequently, when lines are knocked out in one area, power may be lost for miles. Also, when one generator is damaged, as with the severe damage done to sixty (60)-year-old Costa Sur power plant by an earthquake in 2020, it impacts much of the Island. Costa Sur provided a quarter of the Island's power. (See map of distribution lines on following page)

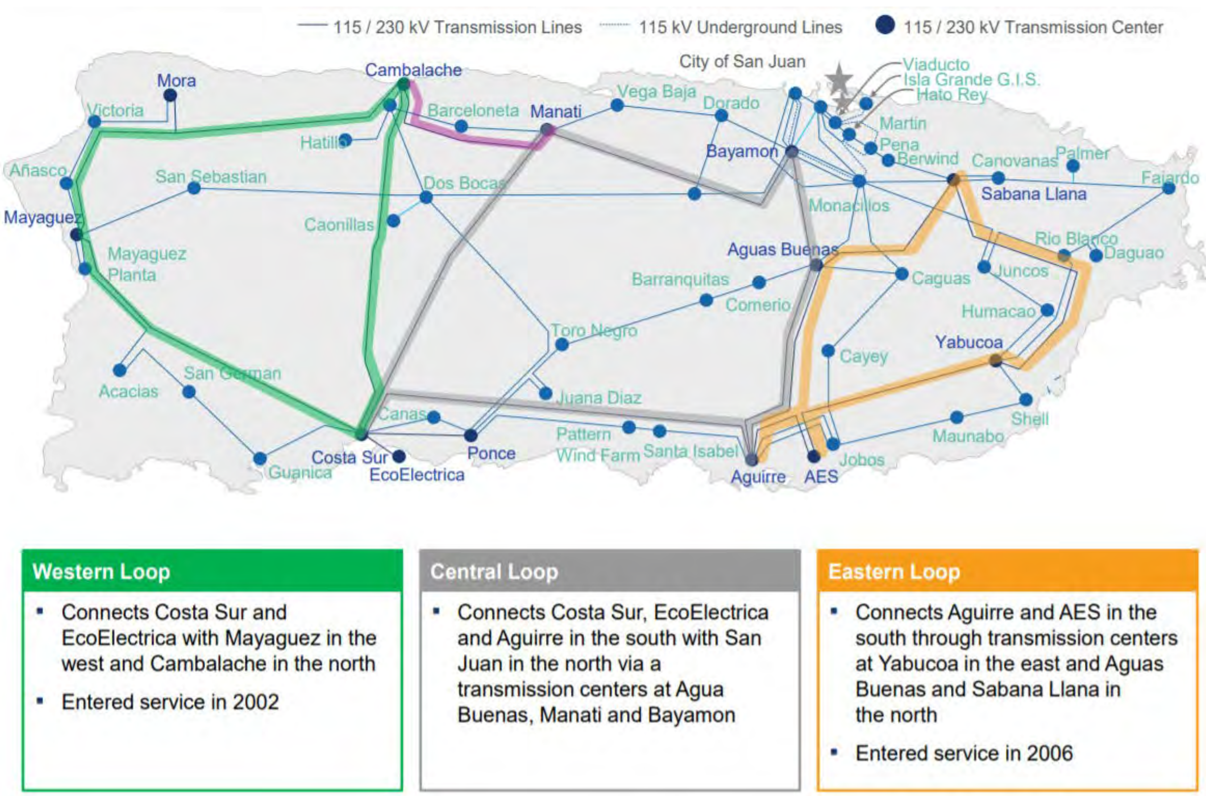

Figure 55. Map of PREPA transmission and distribution lines. Source: 2019 Fiscal Plan for the

Following Hurricanes Irma and María, eighty percent (80%) of the transmission and distribution network collapsed, leaving most customers without power for weeks or months, some as long as a year.[125] A prolonged disruption of this nature has dire implications as power is essential for operating life-saving medical equipment such as nebulizers and oxygen machines, to refrigerate medications, and for the preservation of essential foods.

The vulnerabilities of the infrastructure are exacerbated by financial constraints. PREPA financial statements as of June 30, 2014, show debts totaling over $11.7 billion. The

[125] Special Report: The bankrupt utility behind Puerto Rico's power crisis. Reuters. October 4, 2017. Accessed at: https://www.reuters.com/article/us-usa-puertorico-utility-specialreport/special-report-the-bankrupt-utility-behind-puerto-ricos-power-crisis-idUSKBN1C92B5

Authority's financial difficulties have been known for years and have transformed this public corporation into an unsustainable burden for Puerto Rico. A bill passed in 2016, known as the Transparent Bill, was an effort to rectify PREPA's practices of adding disguised charges to residents' bills designed to pay PREPA's debts.[126] Its fragile fiscal situation forced the Authority to file for bankruptcy under Title III of the 2016 Puerto Rico Oversight, Management, and Economic Stability Act (**PROMESA**).

Average rates across all sectors in Puerto Rico are higher than rates in forty-eight (48) of the fifty (50) states. Only Hawaii and Alaska have higher average rates.[127]

Fossil-Fuel Dependence

According to one report by the Puerto Rican Public Private Partnerships Authority (P3), sixty percent (60%) of PREPA's operating costs go to purchasing fuel which must be imported to the mainland and distributed via trucks throughout the Island.[128] The problems with this are many:

- Fossil fuels, including natural gas, are expensive and fuel prices are projected to increase according to PREPA's own Integrated Resource Plan (**IRP**).
- Importing fuel leaves the Island dependent not only for electric power but, by extension for residents' very lives, on the fuel market and the companies contracted to provide the fuel.
- Fossil fuels must be transported by truck; following Hurricane María, many roads were impassable, and it was impossible to get fuel to generation stations and some communities.

Fossil fuels are polluting, creating carbon dioxide (CO2) and harming the environment. Puerto Rico's own Energy Public Policy Act dictates that the Island reaches forty percent (40%) renewable energy by 2024 and 100% by 2050.

In summer of 2019, PREPA released an IRP with various scenarios for modernizing the grid, each of which would cost upwards of $14 billion out of the $40 billion allocated for recovery. Part of PREPA's plan is to outsource the transmission and distribution to a consortium of companies. In PREPA's IRP, its preferred plan called for 2.6 gigawatts (**GW**) of solar to be installed over the next eighteen (18) years. In the next five (5) years, by 2025, however, it called for the installation of infrastructure and power plant renovations to accommodate 2.2 GW of liquified natural gas (**LNG**). The plan also includes the installation of three (3) offshore receiving stations for the import of LNG. Presumably this infrastructure would be supported by long term contracts to import LNG.

While the existing generation plants would be retro-fitted for LNG, the IRP also calls for the creation of eight (8) "mini-grids," smaller, vertically integrated LNG plants with more

[126]CEPR-AP-2016-0002, Puerto Rico Cong. Accessed at: https://energia.pr.gov/wp-content/uploads/2016/08/16-agosto-2016-Resolution-and-Order-Transparent-Bill-Approval-Procedure-1.pdf (2016) (enacted).
[127] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. Puerto Rico - Territory Energy Profile Analysis - U.S. Energy Information Administration (EIA), 21 Nov. 2019. Accessed at: www.eia.gov/state/analysis.php?sid=RQ
[128] Puerto Rico Public Private Partnerships Authority, P3 Summit Puerto Rico, 20 April 2017.

localized transmission and distribution lines so that if one (1) plant goes down because of a natural disaster, the others will not be impacted, and island-wide blackouts will presumably cease. However, the new transmission and distribution consortium said their plan is somewhere "down the middle" between vertical and distributed generation.[129]

A plan to switch from petroleum to LNG as an interim measure before investing in renewables would require significant investment in LNG receiving terminals and conversion of existing power generators. It would not solve the problem of Puerto Rico's energy dependence, nor the problem of transporting fuels by truck when roads are down. This also conflicts with Puerto Rico's Climate Change Mitigation, Adaption, and Resiliency Law or the Puerto Rico Energy Public Policy Act—which call for Puerto Rico's power system to be broken up into microgrids that run on increasing levels of renewable energy.

This also does not solve the problem of rising prices which already comprise sixty percent (60%) of PREPA's operating cost and cause Puerto Rico to pay higher fuel prices than the other forty-eight (48) states. The chart below shows the relative cost of LNG to diesel and other fuels.[130]

NATIONAL AVERAGE PRICE BETWEEN April 1 and April 15, 2020

Fuel	Price
Biodiesel (B20)	$2.36/gallon
Biodiesel (B99-B100)	$3.51/gallon
Electricity	$0.13/kWh
Ethanol	$1.75/gallon
Natural Gas (CNG)	$2.19/GGE
Liquefied Natural Gas	$2.73/DGE
Propane	$2.73/gallon
Gasoline	$1.91/gallon
Diesel	$2.61/gallon

Figure 56. Source: Clean Cities Alternatives Fuel Price Report April 2020[131]

Supporting the existing system, much less augmenting it, is expensive. The cost to the US of restoring power to Puerto Rico after Hurricane María was $3.9 billion according to the

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[129] Merchant, Emma Foehringer. "Puerto Rico Selects New Grid Manager, Prompting Concerns." Greentech Media, Greentech Media, 25 June 2020. www.greentechmedia.com/articles/read/puerto-rico-selects-new-grid-manager-concern-follows.

[130] "Fuel Prices." Alternative Fuels Data Center: Fuel Prices, updated June 2020, https://afdc.energy.gov/fuels/prices.html

[131] Clean Cities Alternative Fuel Price Report, Clean Cities, US Department of Energy, April 2020. Accessed at: https://afdc.energy.gov/files/u/publication/alternative_fuel_price_report_april_2020.pdf

GAO.[132]; that did not include upgrades or hardening the system. When an earthquake severely damaged the sixty (60)-year-old Costa Sur power plant that provided a quarter of Island's power, PREPA asked for $1.2 billion.[133] for temporary power generation while it repaired the plant at an unspecified cost.

Meanwhile the Puerto Rico Energy Public Policy Act, passed in April 2019, requires Puerto Rico to shift to forty percent (40%) renewables by 2025; sixty percent (60%) by 2040; and 100% by 2050.

Energy Interdependencies

The Electricity subsector and the Communications sector are highly interconnected. The Communications sector provides key monitoring and control services to the Electricity subsector, while the Electricity subsector provides power that is necessary for Communications sector operations.

The Energy sector and the Water and Wastewater Systems sector have significant interdependencies: water is used in all phases of energy production and electricity generation, while electricity and other fuels are used to extract, convey and deliver water and to treat wastewater prior to its return to the environment.

Delivery of natural gas into Puerto Rico is presently limited to a single terminal/storage facility, which represents a single point of failure.[134]

Energy Infrastructure Risk Assessment

Based on the results of the PRDOH Risk Assessment, the map below displays Energy infrastructure in relation to medium to high risk areas. The determination of risk is based on the composite risk scores which range from: Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); and High (200 or more).

A little over 275 miles (or twenty-one percent (21%)) of power transmission lines are located in a High, Medium High, or Medium risk area. Approximately thirty-eight percent (38%) of fossil-fuel dependent and renewable energy infrastructure is within one (1) of the three (3) risk areas.

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[132] Puerto Rico Electricity Grid Recovery. Better Information and Enhanced Coordination Is Needed to Address Challenges, 8 Oct. 2019. Accessed at: www.gao.gov/reports/GAO-20-141/

[133] IN RE: Request for Proposals for Temporary Emergency Generation, Government of Puerto Rico Public Service Regulatory Board, Puerto Rico Energy Bureau, April 8. 2020. Accessed at: https://energia.pr.gov/wp-content/uploads/2020/04/2020-04-08-Reply-to-PREPAs-Opposition-to-Joint-Petition-for-Intervention-NEPR-AP-2020-0001.pdf

[134] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 176, May 2018. http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

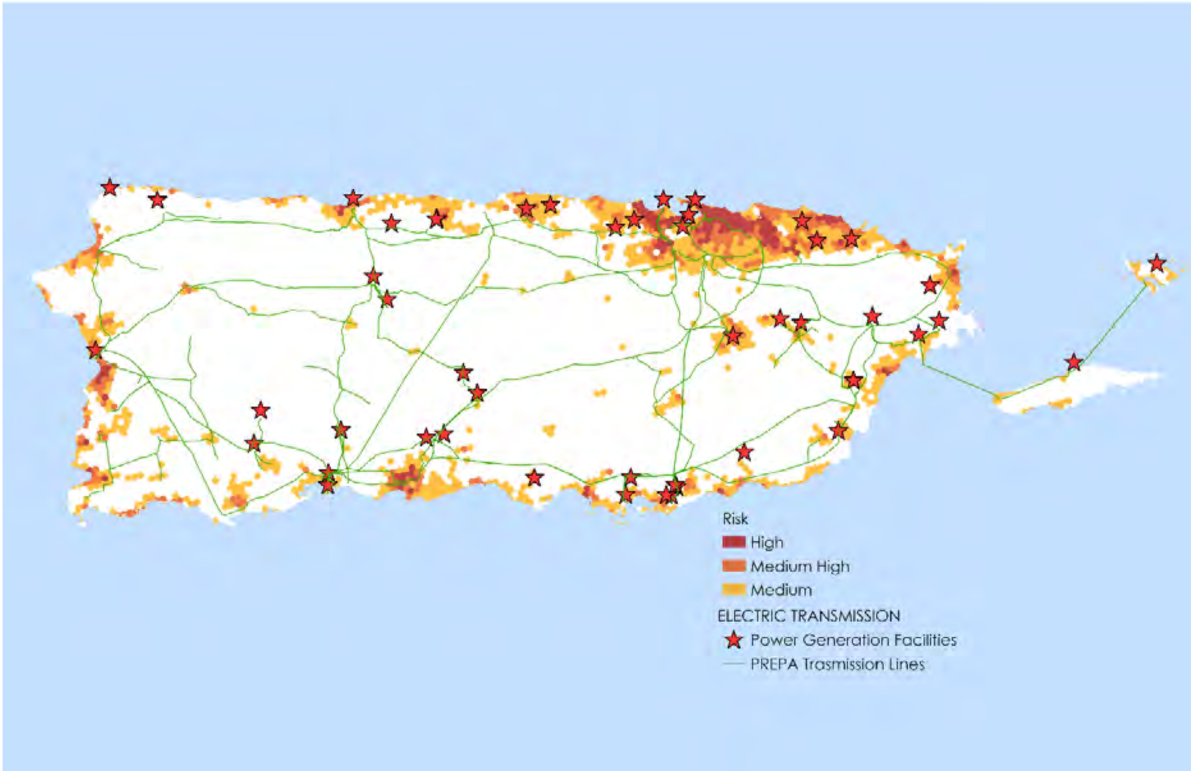

Figure 57. Power Transmission and Distribution Facilities and Proximity to Risk Areas Classified as High, Medium High, or Medium

Total Power Transmission Lines in Risk Areas Classified as High, Medium High, or Medium[135]		
Risk	Total Line Segments in Risk Area (Miles)	Percentage of Total Line Segments
HIGH	33.01	2.55%
MEDIUM HIGH	174.11	13.48%
MEDIUM	68.24	5.28%
Total	**275.35**	**21.31%**

[135] Composite risk scores range from Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); High (200 or more)

Power Facilities in Risk Areas Classified as High, Medium High, or Medium [136]			
Risk	**NAICS [137] Description**	**Total Power Generation Facilities**	**Percentage of Facilities in Risk Area**
HIGH	FOSSIL FUEL ELECTRIC POWER GENERATION	1	5.88%
	Total	**1**	**2.08%**
MEDIUM HIGH	FOSSIL FUEL ELECTRIC POWER GENERATION	3	17.65%
	SOLAR ELECTRIC POWER GENERATION	3	16.67%
	Total	**6**	**12.50%**
MEDIUM	BIOMASS ELECTRIC POWER GENERATION	1	50.00%
	FOSSIL FUEL ELECTRIC POWER GENERATION	4	23.53%
	HYDROELECTRIC POWER GENERATION	1	14.29%
	SOLAR ELECTRIC POWER GENERATION	4	22.22%
	WIND ELECTRIC POWER GENERATION	1	50.00%
	Total	**11**	**22.92%**
Grand Total		**18**	**37.50%**

[136] Composite risk scores range from Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); High (200 or more)
[137] North American Industry Classification System

Communications Lifeline

Telecommunications Sector Profile

Puerto Rico's communication sector is supported by a modern system integrated with that of the US via high-capacity submarine cable providing connectivity to the mainland US, Caribbean, Central and South America and satellite with high-speed data capability.

Competition among network operators has promoted growth with availability of Long-Term Evolution (LTE) coverage increasing to ninety percent (90%). Operators are currently expanding and securing 600 MHz spectrum, LTE reach and launching services based on 5G to a majority of the population. The telephone system consists of a digital telephone system and mobile-cellular services. Most telephone lines are wireless with 687,983 fixed line and 3,390,136 wireless connections as of January 2020, according to the Puerto Rico Telecommunications Regulatory Board (**PRTRB**). [138] Puerto Rico's fixed-line connections rate is twenty-one (21) per 100 persons and mobile-cellular connection rate is 101 per 100 persons, ranking it eighty-eighth (88th) and (139th) in the world.

Puerto Rico is also served by public and private television (TV) and radio stations consisting of more than thirty (30) broadcast TV stations, cable and satellite TV subscription services, and roughly 125 radio stations.

Fixed-broadband subscriptions, through a physical wired connection to the Internet (e.g., coaxial cable, optical fiber) are available on the Island with an estimated 600,000 total connections and eighty percent (80%) of the population having internet access as of July 2016.[139]

Regulatory Framework

The Federal Communications Commission (**FCC**) has federal regulatory authority over telecommunications in Puerto Rico, as in the mainland US. **PRTRB** is the local entity with authority and responsibility for ensuring compliance with the Puerto Rico Telecommunications Act of 1996, and its regulations.[140] The board has authority and responsibility to ensure compliance with its regulations and orders, through rule making, administrative fines, public hearings, subpoenas, mediation, inspections, investigations and audits. The PRTRB's stated mission is to promote fair and equitable competition among companies that offer telecommunications and cable television services, to guarantee to all the citizens of Puerto Rico the availability and enjoyment of said services at a reasonable cost; promote and encourage the economic development of the Island and guarantee optimum quality telecommunications and cable television services. The PRTRB is made up of three (3) associate members, one of which is its President. All members are appointed by the Governor of Puerto Rico, with the advice and consent of the Senate.

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[138] ESTADÍSTICAS DE LA INDUSTRIA DE LAS TELECOMUNICACIONES EN PUERTO RICO, Informe Mensual Enero 2020, Negociado de Telecomunicaciones de Puerto Rico, January 2020.

[139] World Factbook, U.S. Central Intelligence Agency, Retrieved July 8, 2020.

[140] Act No. 213 of September 12, 1996 as amended, 27 LPRA § 265, et seq; known as Puerto Rico Telecommunications Act of 1996.

Vulnerability to Disasters

The Communication sector's vulnerability to disasters was illustrated by Hurricane María. The 2017 Atlantic hurricane season was notable for the devastation wrought to critical infrastructure, resulting in cascading failures of the lifeline systems of energy, telecommunications, water, and transportation. The early September 2017 arrival of Hurricane Irma, followed in short order by Hurricane María just two (2) weeks after Irma, largely destroyed the communications infrastructure of Puerto Rico and the USVI.[141] The effect of the 2017 Atlantic hurricane season on communications platforms varied, according to local conditions and topography, the intensity of each storm, the population density of the region hit, and the ability of communications service providers and local emergency management officials to prepare for impact. Hurricane María had the greatest impact on the communications infrastructure among the major storms of the 2017 Atlantic hurricane season. FCC noted that after the hurricanes, and after Hurricane María, ninety-five-point two percent (95.2%) percent of cell sites in Puerto Rico were out of service. All municipalities in Puerto Rico had greater than seventy five percent (75%) of their cell sites out of service. Forty-eight (48) out of the seventy-eight (78) municipalities in Puerto Rico had one hundred percent (100%) of their cell sites out of service.[142]

Wireless service was restored gradually over a six-month period following the hurricanes, considerably longer than for any other storm. After six (6) months, four percent (4%) of cells sites remained out of service (i.e., completely inoperable) in Puerto Rico, outages more typical of a few days after, not many months after, a significant hurricane.

The federal government was unable to prepare communications networks in Puerto Rico for Hurricane María in the same way it did for other recent storms that hit the country's mainland. According to Rear Admiral Ronald Hewitt, the Director of the Office of Emergency Communications for the Department of Homeland Security, "It was impossible to preposition [equipment] because every island got wiped out." Additionally, the strong winds of the Category Five (5) storm took a major toll on the Island. While most communication towers are able to withstand a Level Three (3) hurricane, María's Level Five (5) winds damaged nearly every tower by knocking it down or causing misalignment of the microwave links; requiring a complete rebuilding of the communications network in Puerto Rico. The geographic location of Puerto Rico also made restoration of the system difficult. Cell carriers trying to get equipment to the Island, required a boat or plane, and once on the Island the road conditions made travel inland difficult, as well.[143]

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[141] 2017 Atlantic Hurricane Season Impact on Communications Report and Recommendations, Public Safety Docket No. 17-344, DHS, Page 3, Aug. 2018.

[142] Communications Status Report, FCC, ***Communications Status Report for Areas Impacted by Hurricane Maria, September 21, 2017*** (rel. Sep. 21, 2017). Accessed at: https://www.fcc.gov/document/hurricane-maria-communications-status-report-sept-21

[143] Assessing First Responder Communications. Accessed at: https://homeland.house.gov/activities/hearings/assessing-first-responder-communications

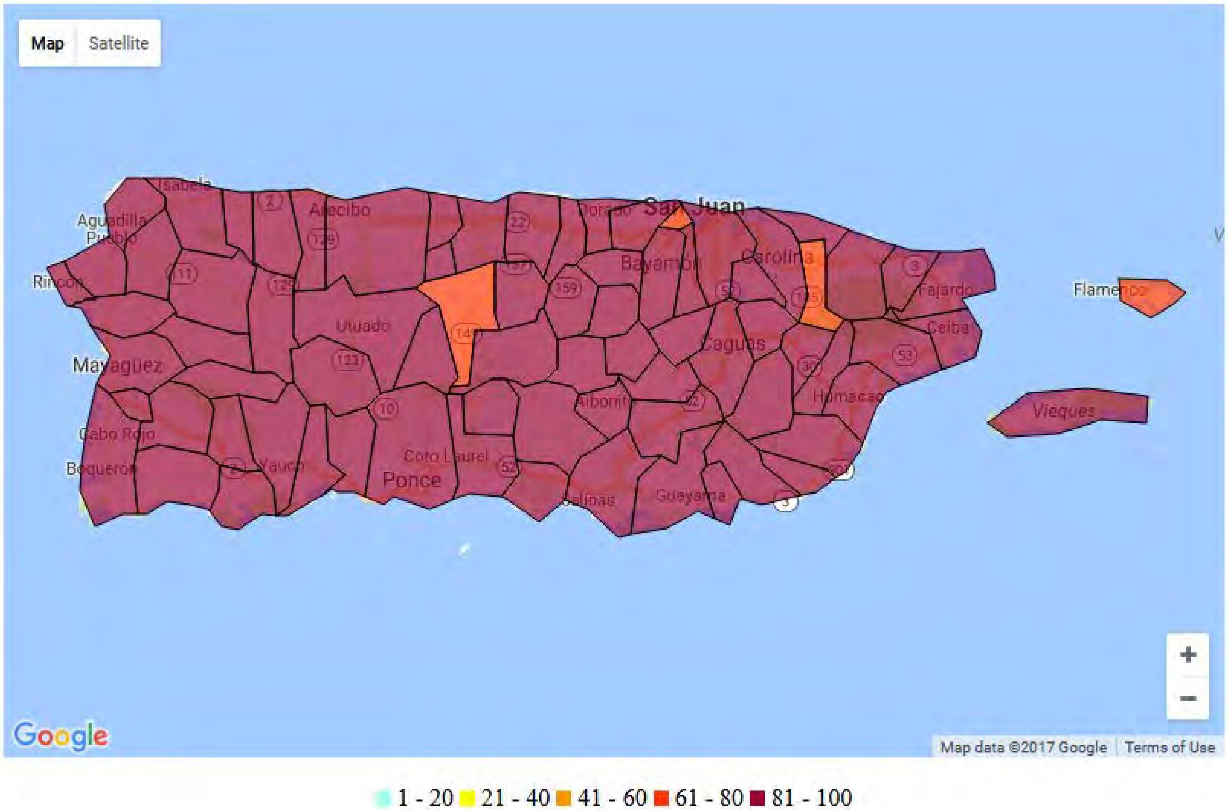

Figure 58. Percent cell services out by municipality on 9/21/2017. Source: 2017 Atlantic Storms Impact on Communications

The map shown above and line graph shown below illustrate that large percentages of cell sites were out of service throughout September and October of 2017 in Puerto Rico and the USVI. Six (6) months after Hurricane María made landfall, four-point three percent (4.3%) and twelve percent (12%) of the cell sites in Puerto Rico and the USVI respectively were still out of service.

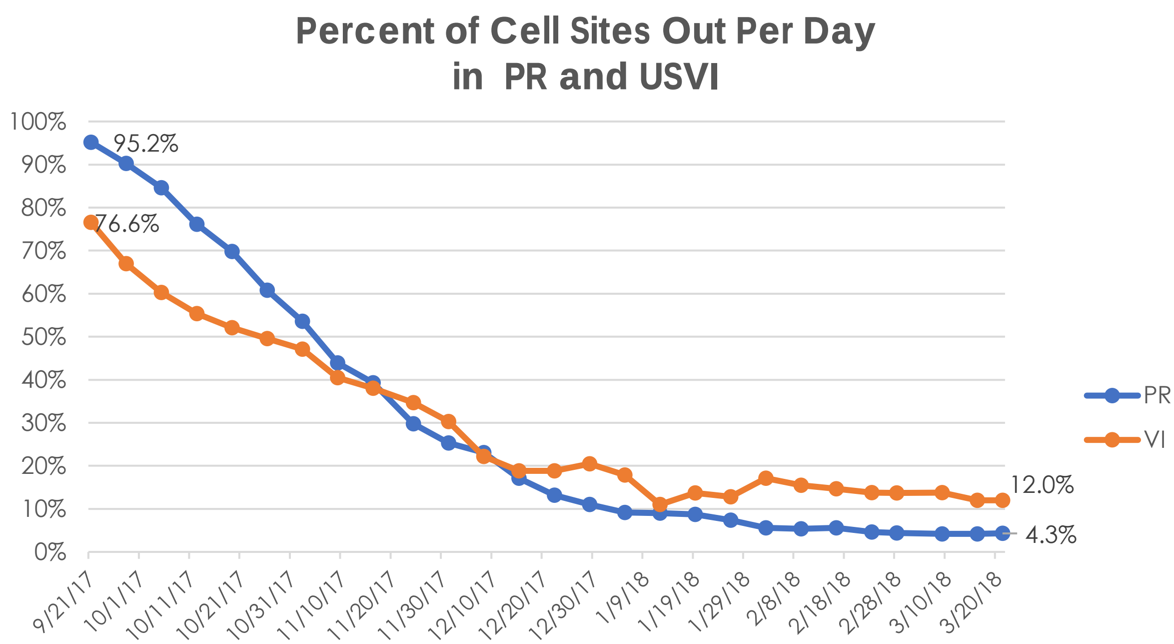

Figure 59. Source: 2017 Atlantic Storms Impact on Communications

Public Safety Access Points (**PSAP**s) are emergency call centers (e.g. police, fire brigade and ambulance). The two (2) PSAPs in Puerto Rico functioned throughout Hurricane María, although not always with the full functionality (location information and call back number) that 911 call center personnel needed to fully carry out their work.

Impact on other Communications Platforms

Communications beyond wireless service also came to a virtual stand-still for weeks after Hurricane María. As of December 6, 2017, several weeks after Hurricane María made landfall, five (5) television stations in Puerto Rico were reported as operational, while 100 were not functioning. Roughly one-third (1/3) of AM and FM radio stations remained out-of-service. Cable system and wireline phone service remained generally non-existent, owing mostly to the lack of power. On the same date, the USVI had no operational television broadcasting, cable system, and wireline service; and only two (2) AM and two (2) FM radio stations were confirmed functioning.[144]

Communications Interdependencies

Communications infrastructure is primarily owned and maintained by private companies. The primary cross-sector dependency of the Communications sector is electricity, which is either provided from commercial power or by onsite generation. Water can be a dependency for facilities that require heating, ventilation, and air-conditioning or cooling

[144] Communication State Report for Areas Impacted by Hurricane Maria, December 6, 2017. Accessed at: https://www.fcc.gov/document/hurricane-maria-communications-status-report-dec-6 (last visited Jul. 2, 2018).

(e.g., data centers). Surface transportation routes are generally necessary to enable access to communication infrastructure throughout Puerto Rico.[145]

At the publishing of the DHS Interdependency Assessment, the following providers were operating in Puerto Rico:

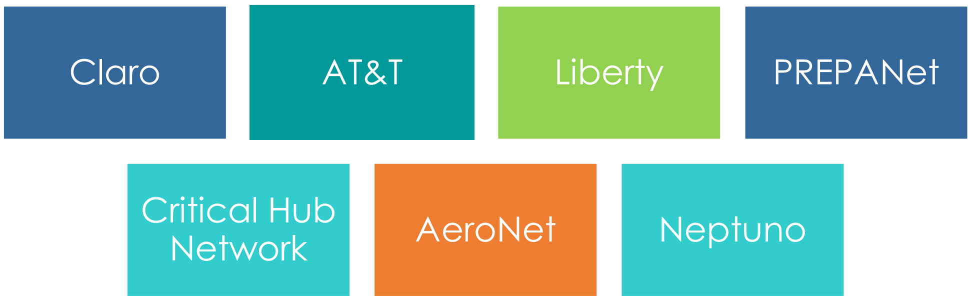

Figure 60. Illustration of private sector communications providers in Puerto Rico

There is significant interdependence among all of these providers including their reliance on PREPA for electricity, on the Puerto Rico Aqueducts and Sewers Authority (**PRASA**) for water and wastewater at their facilities, and on Claro for access to tandem facilities.

In addition, Hurricane María caused significantly more damage to the telecommunications and other critical infrastructures (particularly the electrical and transportation infrastructures) in Puerto Rico and the USVI, resulting in much longer recovery times compared to Hurricane Harvey's effect on Texas, Hurricane Irma's effect on Florida, or Hurricane Nate's effects along the Gulf Coast. The Electrical and the Communications sectors are highly interconnected with the Communications sector providing key monitoring and control services to the Electrical sector, while the Electrical sector provides power necessary for Communications sector operations. Due to the interdependency of the two (2) systems, the damage to the electrical grid caused cascading failures across all of Puerto Rico's critical infrastructure systems, including communications. In addition, the logistical challenges (non-operational ports, unpassable roads, etc.) of getting material to Puerto Rico and the USVI that were necessary for recovery of the communications system added to the delay. Downed broadcasting antennas, lack of power, a dearth of resources, destroyed telephone poles, and similar factors, combined to devastate communications in Puerto Rico for months. The impact to communications infrastructure caused by Hurricane María disrupted the normal distribution of food products in various ways, including loss of normal communications/Internet capabilities at most of the facilities that comprise the food supply chain, such as warehouses and points of sale. The loss of power and communications incapacitated local disaster response functions.

[145]. *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 83, May 2018. http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

Communications Lifeline Risk Assessment

Based on the results of the PRDOH Risk Assessment, the map below displays Communications infrastructure in relation to medium to high risk areas. The determination of risk is based on the composite risk scores which range from: Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); and High (200 or more).

Approximately forty-four percent (44%) of Communications infrastructure for AM radio, Broadband Radio Service and Educational Broadband, Cellular, FM radio, Land/Mobile Broadband, and microwave are in High, Medium High, and Medium risk areas.[146] A total of eleven-point five eight percent (11.58%) is located in high risk areas.

Because this privately-owned infrastructure is highly dependent on energy infrastructure, PRDOH has observed that approximately twenty-one percent (21%) of the PREPA-dependent broadband infrastructure is in High, Medium High, and Medium risk areas.

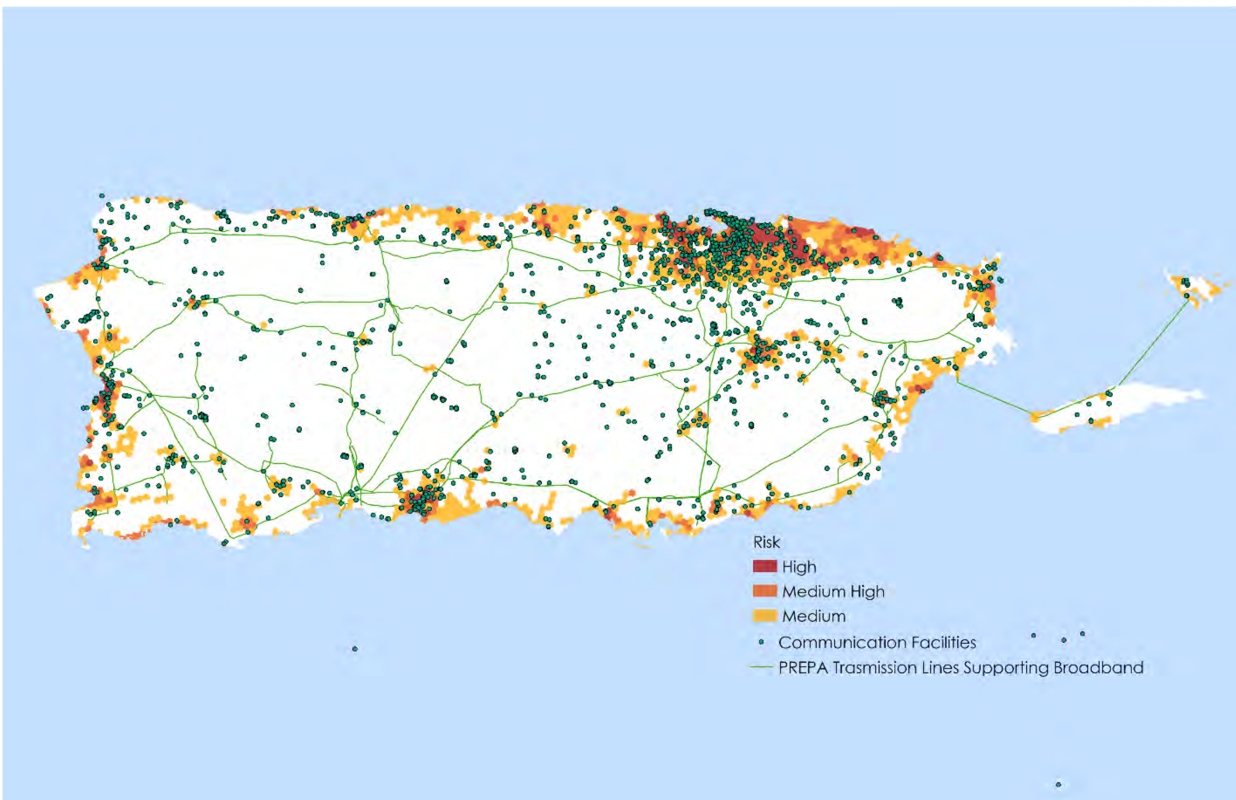

Figure 61. Communication Facilities and Proximity to Risk Areas Classified as High, Medium High, or Medium

[146] Composite risk scores range from Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); High (200 or more)

Communication Facilities in Risk Areas Classified as High, Medium High, or Medium[147]			
Risk	Type	Total	Percent of Total Facilities
HIGH	AM	12	15.19%
	Broadband Radio Service and Educational Broadband	2	1.48%
	Cellular	3	3.23%
	FM	7	6.93%
	Land/Mobile Broadband	22	16.92%
	Microwave	774	11.83%
	Total	**820**	**11.58%**
MEDIUM HIGH	AM	12	15.19%
	Broadband Radio Service and Educational Broadband	16	11.85%
	Cellular	8	8.60%
	FM	1	0.99%
	Land/Mobile Broadband	19	14.62%
	Microwave	1000	15.28%
	Total	**1056**	**14.91%**
MEDIUM	AM	23	29.11%
	Broadband Radio Service and Educational Broadband	17	12.59%
	Cellular	6	6.45%
	FM	6	5.94%
	Land/Mobile Broadband	19	14.62%
	Microwave	1147	17.52%
	Total	**1218**	**17.20%**
Grand Total		**3094**	**43.68%**

Broadband Infrastructure Associated with PREPA Transmission Lines in Risk Areas Classified as High, Medium High, or Medium[148]		
Risk	Total Line Segments in Risk Area (Miles)	Percentage of Total Line Segments
HIGH	33.01	2.55%
MEDIUM HIGH	174.11	13.48%
MEDIUM	68.24	5.28%
Total	**275.35**	**21.31%**

[147] Composite risk scores range from Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); High (200 or more)
[148] Composite risk scores range from Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); High (200 or more)

Food, Water, and Shelter Lifeline

Water and Wastewater Lifeline Sector Profile

Water and wastewater infrastructure in the water lifeline sector handles the management, supply, treatment, distribution, and collection network that ensure a community has access to adequate quantities of clean, potable water as well as safe treatment and disposal of sewage necessary to protect public health. The water sector in Puerto Rico can be broadly divided into four (4) subsectors including:

- water source and supply,
- drinking water and wastewater,
- storm water and flood mitigation, and
- water resource management systems.

Collectively, these systems include the assets necessary for water storage, distribution, conveyance, and treatment as well as the protection of communities and natural ecosystems from flooding and water quality impacts.

Water Source and Supply Subsector

Approximately forty-five percent (45%) of Puerto Rico's public drinking water supply is surface water stored in reservoirs created by dams owned and operated by both public and private agencies. The National Inventory of Dams identifies a total of thirty-eight (38) dams in Puerto Rico, and twenty-four (24) of them are owned by public utilities (PRASA or PREPA). [149] All of these dams are rated as having a high damage potential in the event of failure. The management, operation, and maintenance of dams across Puerto Rico are delegated among PRASA, PREPA, and Puerto Rico Department of Natural and Environmental Resources (**DNER**), and to a lesser extent, other state and federal agencies. As part of the water storage infrastructure, these dams provide multiple functions—hydropower generation, water supply, and flood mitigation. Because of high rates of sedimentation, regular dredging is typically carried out to maintain channel navigability, to preserve dam storage capacity, and to retain the design life and purpose of dams and levees. However, dam maintenance has been a challenge due to the combination of impacts from Hurricanes María and Irma, high dredging costs, and budgetary constraints in DNRA.

In addition to physical water infrastructure, Puerto Rico has critical natural assets that support its water systems. Because of mountainous topography and tropical precipitation, Puerto Rico is drained by 224 rivers and 553 streams that are delineated into 134 hydrological watersheds. These watersheds are bounded in many cases by one (1) or more of the three (3) mountain ranges that run from east to west—Cordillera Central, Sierra de Cayey, and Sierra de Luquillo. Within this large number

[149] National Inventory of Dams. Accessed at: https://nid.sec.usace.army.mil/ords/f?p=105:113:15212158439609::NO:::

of watersheds are fifty-four (54) dominant river systems that discharge to the ocean.Error! Bookmark not defined.

Water and Wastewater Sector

In Puerto Rico, the vast majority of drinking water is treated and distributed by PRASA, serving approximately ninety-seven percent (97%) of the population. PRASA's system comprises raw water supply and intake facilities, water treatment plants, and distribution infrastructure. Facilities and operations are divided into five (5) management regions: Metro (including San Juan), North, South, East, and West. Each region is further divided into operational zones and water service areas that are served by a single treatment plant.[150] PRASA maintains over 1.1 million drinking water connections and approximately 700,000 wastewater connections. PRASA owns and operates 114 water treatment plants (WTPs) that are located across the five (5) service regions. Together, they produce 508 million gallons per day (**MGD**) of drinking water. PRASA also owns and operates fifty-one (51) wastewater treatment plants (WWTPs), with a total treatment capacity of 210 MGD of sewage. PRASA operates eight (8) dams and twenty (20) minor reservoirs for water storage that are owned and managed jointly with PREPA, the Puerto Rico Department of Agriculture, and DNER. PRASA also controls more than 4,000 ancillary assets. Its entire system comprises over 20,000 miles of pipeline across Puerto Rico.[151]

While PRASA provides drinking water to most Puerto Rico residents, approximately 76,000 residents in over 200 small communities are serviced by non-PRASA drinking water suppliers. Sources estimate there to be approximately 242 non-PRASA community drinking water systems.[152] These systems serve small and potentially hard-to-reach populations. In addition, fifty-seven (57) noncommunity systems in Puerto Rico provide drinking water to hospitals, schools, industrial facilities, and private companies.

[150] DHS, Puerto Rico Drinking Water Sector Characterization, Infrastructure Protection, Washington, D.C.: U.S. Department of Homeland Security, 2018

[151] Preston, Benjamin L., et. al., Beyond Recovery – Transforming Puerto Rico's Water Sector in the Wake of Hurricanes Irma and Maria. Homeland Security Operational Analysis Center. pg. 5. Apr. 2019.

[152] Ramirez-Toro, G.I. and H. Minnigh, "Water System Resilience in Disasters: Puerto Rico's Experience," presented at Water Science and Technology Issues for the Nation.

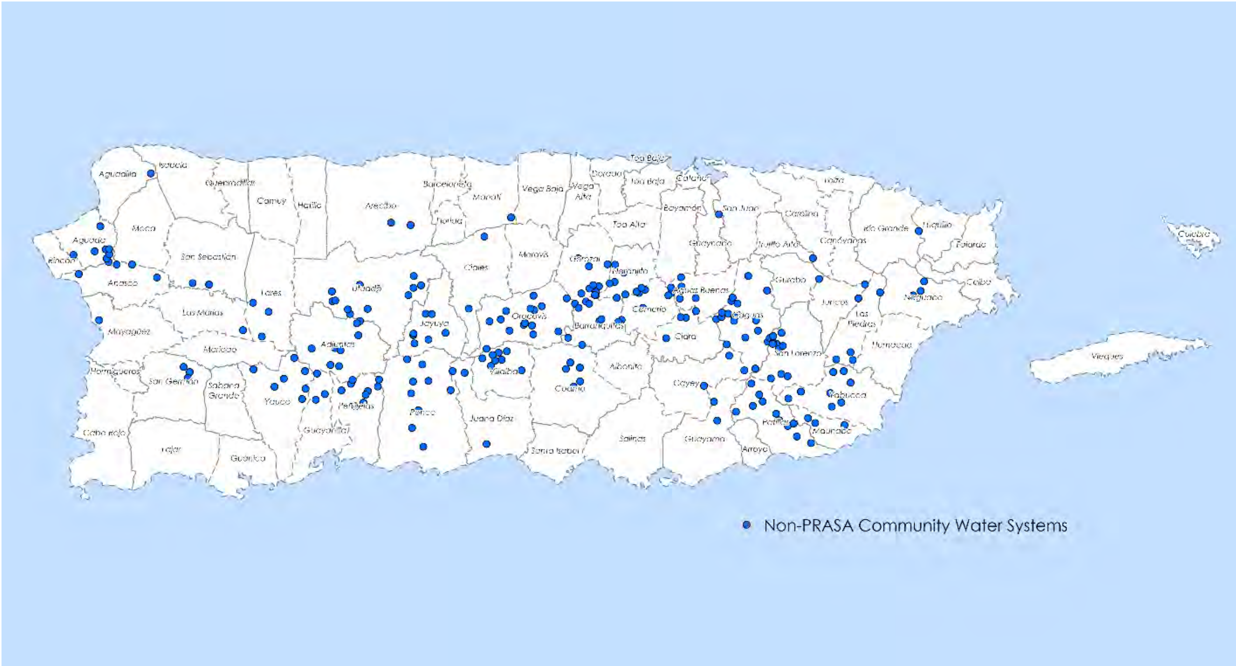

Figure 62. Non-PRASA Community Water Systems

The majority of Puerto Rico's population not serviced by PRASA's wastewater systems (forty-one percent (41%)) use an estimated 500,000 septic systems for wastewater discharge.

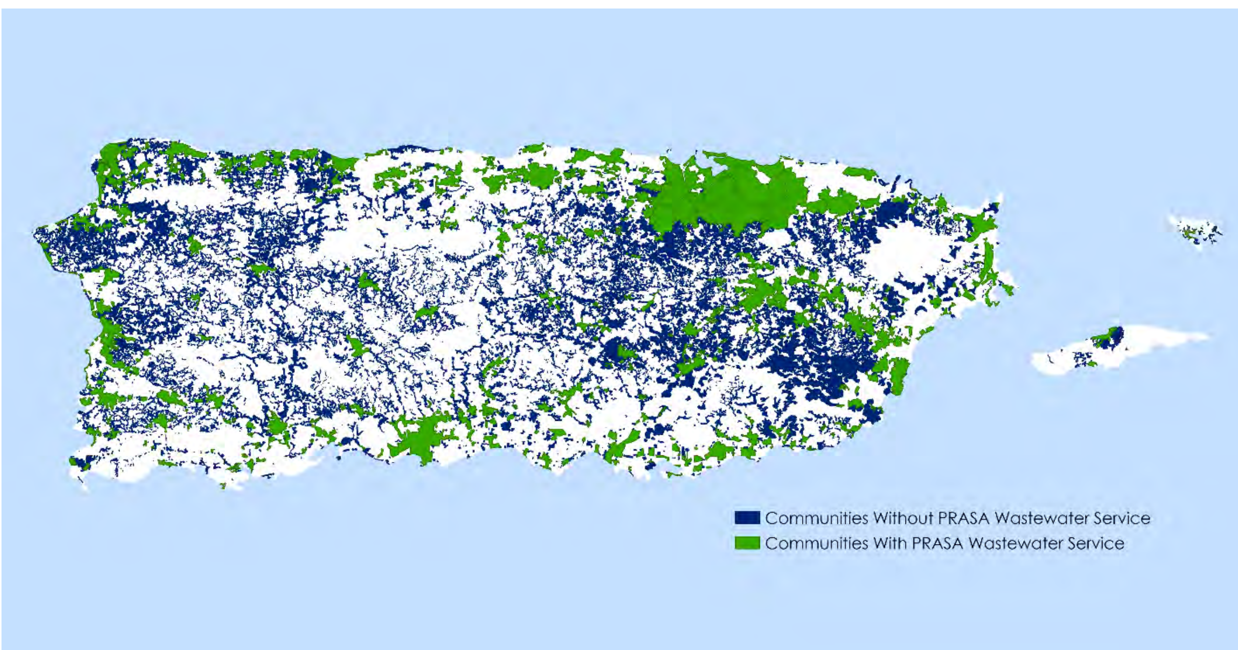

Figure 63. Communities with and Communities without PRASA Wastewater Service

The water distribution network also includes canals, and aqueducts to transmit raw source water for agricultural and domestic purposes and for treated potable water distribution throughout the community. The canals are largely under the PREPA's authority, while the aqueducts to transmit large amounts of treated potable water are owned and operated by PRASA.

Water and Wastewater Interdependencies

The Water and Wastewater Systems sectors are heavily interdependent on the Energy sector. To that extent, the greatest vulnerability of the sectors is the loss of power due to hurricanes, heavy rain events, lightning, tsunamis, and earthquake, which disrupts the ability of pump and treatment facilities to provide water and wastewater treatment to the community, as well as the monitoring and control of these facilities.

The DHS interdependency assessment aptly characterizes this shared interdependence in these statements:

> A key finding from a 2016 US National Infrastructure Advisory Council report on Water sector resilience in the United States found that, among infrastructure facilities that depend on water for core operations, services degrade fifty percent (50%) or more within eight (8) hours of losing drinking water services. [153]
>
> Wastewater systems in Puerto Rico depend on a variety of external inputs and resources to maintain normal operations. A wide range of physical infrastructure in industries and other critical infrastructure relies heavily on the proper functioning of wastewater systems.[154]

The Economic Impact of Interdependencies

According to the interdependency assessment, over forty-two percent (42%) of direct economic output in Puerto Rico in 2016 was driven by pharmaceuticals, medical devices, and agriculture and food industries.[155]

The food industry serves as one example of how an interdependent infrastructure system, when vulnerable, can have significant negative economic impact.

> Hurricane María disrupted the normal distribution of food products in various ways: loss of normal power, water, and communications/Internet capabilities at most of the facilities that comprise the food supply chain, including warehouses and points of sale; significant congestion at the Port of San Juan, due in part to the accumulation of thousands of containers that were not being delivered to their

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153 *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, page 106, May 2018. http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

154 *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 123 May 2018. http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

155 *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 22, May 2018. http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

customers for various reasons; and transportation challenges, especially in more rural areas, caused by blocked and damaged roadways. [156]

As a result, the interdependency assessment concluded that:

- In general, improving the resilience of essential services (e.g., electricity, communications, and transportation) in specific areas of the island will result in corresponding improvements in the resilience of food retail locations in those locales. [157]
- Many of the food-related challenges caused by Hurricane María relate directly to the fact that Puerto Rico must import the vast majority of its food. However, Puerto Rico has the ability to reduce—though not eliminate—this reliance by producing a larger share of food locally. [158]

More generally, the assessment purported that:

- Improving the resilience of infrastructure assets and systems serving manufacturing facilities benefits entire communities. The positive cascading effects that would result from comprehensive infrastructure improvements, driven by the largest users and economic engines within the community, may also increase the efficiency of the infrastructure and reduce service rates for all customers. [159]

Vulnerability to Natural and Human Caused Disasters

The water resource system is vulnerable to natural and human-caused events as was evident during the Hurricanes Irma and María. The water system remains susceptible to Island-wide service disruptions, primarily due to the loss of power, as experienced during Hurricanes Irma and María and the recent earthquakes. Flooding from any cause and earthquakes can also cause physical damage to the infrastructure. In addition, the water sector is vulnerable to the impacts of drought on the water supply, resulting in shortages and the need for water rationing. Large areas of Puerto Rico have recently experienced drought as a result of increased sediment in water reservoirs after the hurricanes, with a previous severe drought occurring as recently as 2015-2016. Furthermore, water sector facilities are vulnerable to human-caused disasters such as construction related pipeline breaks and terrorism. Because of the critical functions that water, and wastewater services play in the maintenance of public health, enabling commerce and economic activity as well as conserving natural ecosystems and wildlife, water and wastewater

[156]. *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 195, May 2018. http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

[157] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 195, May 2018. http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

[158] *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 195, May 2018. http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

[159]. *Infrastructure Interdependency Assessment Puerto Rico*, Department of Homeland Security, Office of Infrastructure Protection, Page 192, May 2018. http://www.camarapr.org/Camara-en-Accion-18-19/17-nov-8/gob/PR-Infrastructure-Interdependency-Assessment-Report-Sept-2018.pdf

system resilience is critical to mitigation across multiple sectors. By increasing the resiliency of the water sector, Puerto Rico has the ability to mitigate future disruptions in the delivery of this life-giving resource critical to sustaining all sectors of the Puerto Rican community.

Vulnerability to Weather Events

Hurricane and Severe Rain Events

The extent of vulnerability of the water sector to disruptions caused by hurricanes was illustrated by the impacts of Hurricanes Irma and María. The 2017 hurricane season caused a broad range of damages to Puerto Rico's water sector and its various subsectors. There was loss of drinking water services throughout much of Puerto Rico as well as disruption of, or damage to, wastewater infrastructure such as sewage treatment plants. These consequences were either caused, or exacerbated, by widespread loss of electrical power to water and wastewater assets, including treatment plants and pumping stations. The hurricanes also revealed vulnerabilities in municipal storm water management systems stemming from deferred maintenance, clogging, and inadequate capacity. In addition, significant damage was caused to some dams, particularly the Guajataca Dam in northern Puerto Rico, and various flood mitigation levees.

Immediately following Hurricane María, all PRASA customers lacked drinking water; 40 of PRASA's 114 drinking water plants were damaged and out of service because of debris or inundation surrounding water intakes; and 800 drinking water pumping stations lacked power and were out of service. In addition, twenty-two (22) of the fifty-one (51) wastewater treatment plants were nonoperational; three (3) facilities were fully inundated; 222 of PRASA's 714 sanitary pumping stations were out of service and those that were functional were operating on alternative power sources. Significant damage to trunk sewers caused major sewage overflows, particularly at intersections with surface water. Because of these outages, over 13.7 billion gallons of untreated wastewater were discharged into the San Juan metropolitan area after energy failures at PRASA WWTPs and wastewater pumping stations. Estimates also show 780 million to 1,193 million gallons of untreated wastewater were discharged near Manatí, Mayagüez, and Ponce.[160] Figure 20 illustrates the pervasive nature of hurricane damages experienced by drinking water and wastewater assets. Although the large majority of water and wastewater treatment plants were again operational five months after Hurricane María, they were operating below their full operational capacity.

[160] National Oceanic Atmospheric Administration, Quantifying Sewage Contamination into the Environment: A Rapid Assessment in Support of the Natural and Cultural Resources RSF, May 2018

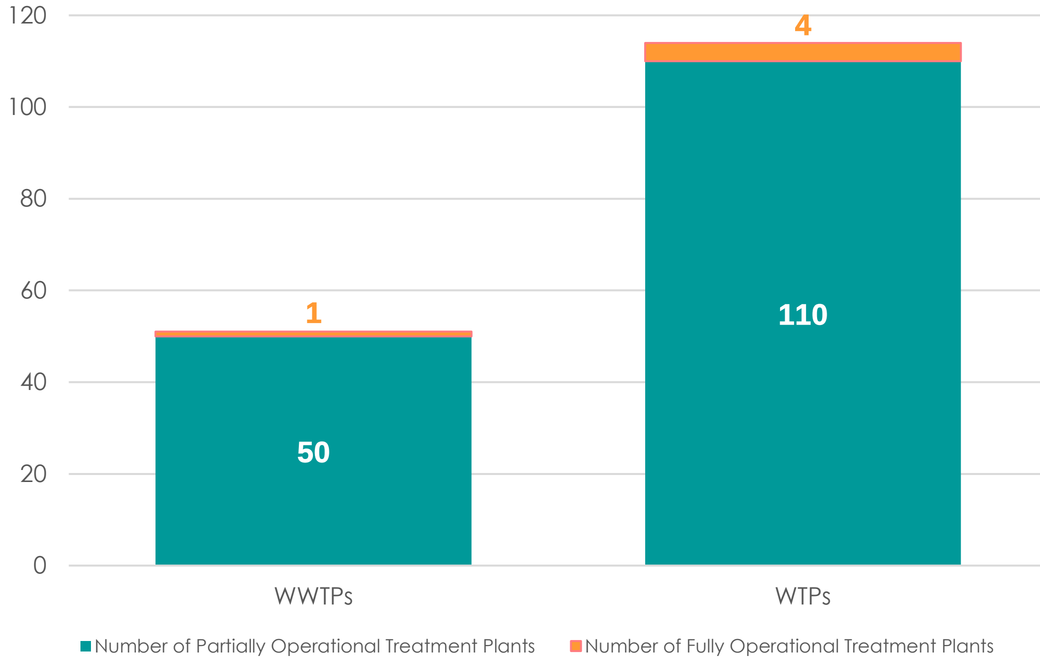

Figure 64. Operational Status of PRASA Water and Wastewater Facilities 6-months post Hurricane SOURCE: U.S. Environmental Protection Agency, "PRASA Before and After the Hurricane," February 28, 2018.

The figures above and below illustrate that damage was widespread throughout Puerto Rico; but also reveal damages were concentrated in areas of high population density and therefore higher asset exposure, such as the greater San Juan area.

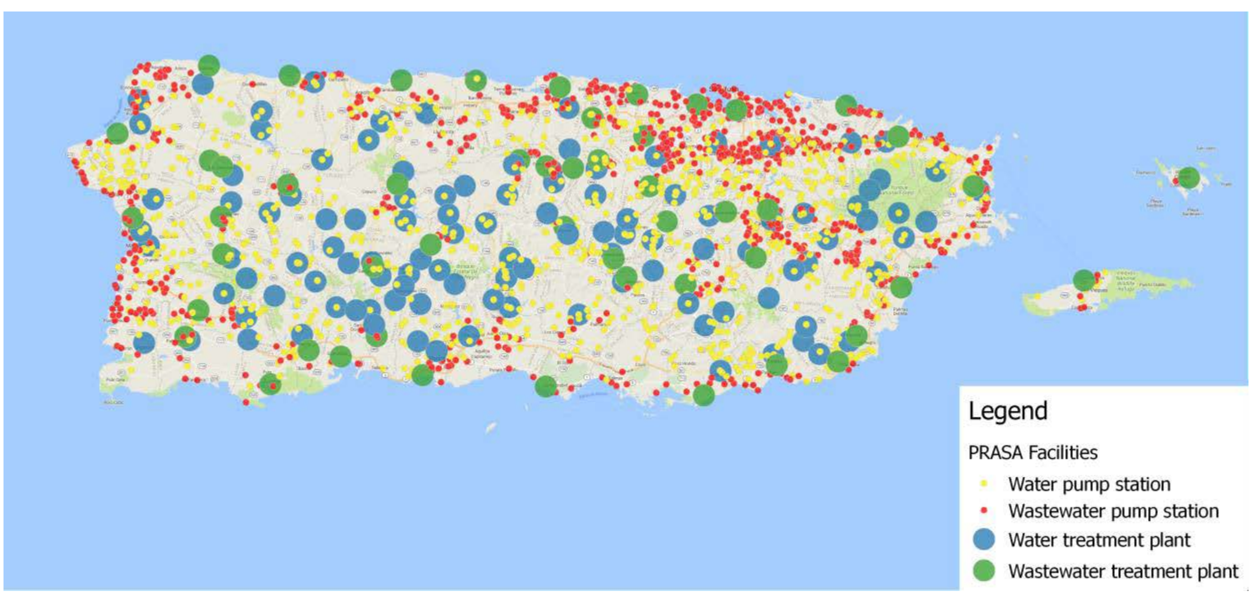

Figure 65. PRASA System Damage by Hurricanes Irma and María. Source: Puerto Rico Aqueduct and Sewer Authority, "PRASA Damage Inventory," May 18, 2018.

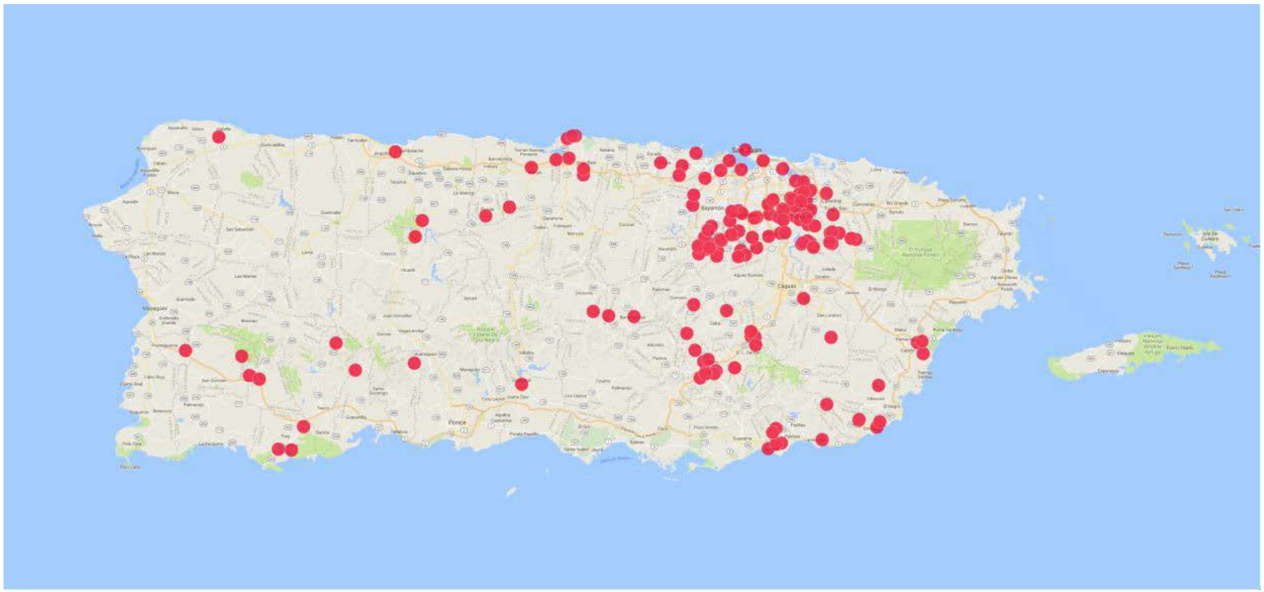

Figure 66. PRASA Facility with Generator Damage by Hurricanes Irma and María. Source: Puerto Rico Aqueduct and Sewer Authority, "PRASA Damage Inventory," May 18, 2018.

Non-PRASA water systems suffered impacts by Hurricanes Irma and María similar to the PRASA owned facilities. Assessments performed by FEMA's Water Task Force in the wake of Hurricane María (between October and November 2017) classified the operational status of 236 out of the 244 non-PRASA systems. A review of these status assessments indicated damage to water distribution piping and storage tanks at sixty (60) and sixty-five (65) sites, respectively, with some of these damages reportedly caused by landslides. Clogged piping/intakes and site inaccessibility caused by debris, were also reported. There were also some instances of damage reported to chlorination systems, pumps, and local infrastructure (e.g., roads that prevented access to water systems). In addition, damaged generators were reported. The primary impact of the storms on non-PRASA drinking water facilities, however, was the loss of power that rendered many of the community well and surface pumps inoperable. Stormwater and Flood Mitigation assets were also vulnerable to the impacts of Hurricanes Irma and María caused by power disruptions, flooding, and landslides, including damaged culverts and bridges, collapsed pipes, clogging by sedimentation, and flooded pump stations. According to the Governor's Build Back Better Puerto Rico report from November 2017, thirteen (13) levee systems were damaged by the storms and were in need of repair to restore full integrity. The map on the following page shows the extent of the impacts to the storm water assets from Hurricane María.

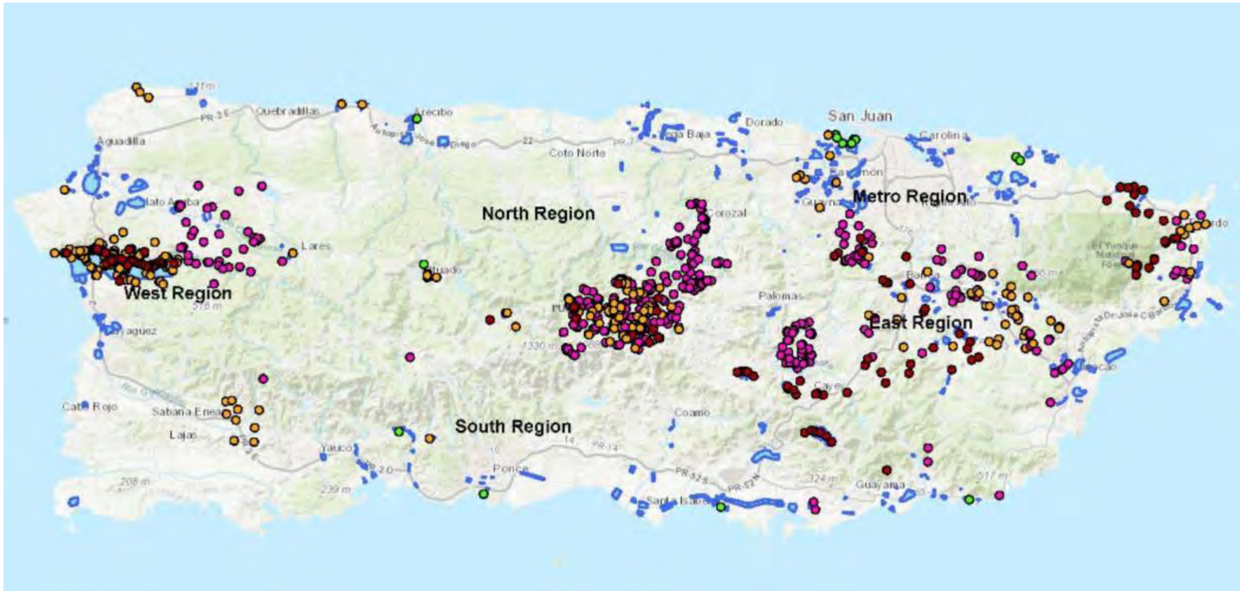

Figure 67. Stormwater System Damages due to Hurricane María. SOURCE: Benjamin L. Preston, et. al., Beyond Recovery – Transforming Puerto Rico's Water Sector in the Wake of Hurricanes Irma and María. Homeland Security Operational Analysis Center. Apr. 2019.[161]

Drought

Since record-keeping began in 2000, the longest duration of drought in Puerto Rico lasted eighty (80) weeks beginning on May 5, 2015 and ending on November 8, 2016. The most intense period of drought occurred the week of September 1, 2015, where exceptional drought affected twenty-five percent (25%) of Puerto Rico land. [162] One very prominent effect of drought is on the supply of potable water. About 1.3 million inhabitants (about 35 percent (35%) of the population of the Island) live in the San Juan Metropolitan area and are highly dependent on the sustainable yield of water from several reservoirs. A deficiency of rainfall can be compounded by a reduction in reservoir storage capacity, generally the result of sedimentation within the reservoir. Water yields from the reservoirs are highly dependent on their storage capacity. Recurring droughts and sedimentation-induced reductions in reservoir storage present a compounded challenge to potable water supply in Puerto Rico.[163]

The Lago Loíza reservoir (figure 4) is an example of the impact of reservoir sedimentation on reservoir storage capacity. The capacity of this reservoir has changed over the years from its original design capacity in 1953, generally decreasing with sedimentation. In an attempt to mitigate the deleterious impact of sedimentation on storage capacity, the reservoir storage capacity was increased in 1977, by installing flashboards above the Carraizo dam crest (Webb and Soler-López, 1997), and between 1997 and 1999,

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[161] Map source: Benjamin L. Preston, et. al., Beyond Recovery – Transforming Puerto Rico's Water Sector in the Wake of Hurricanes Irma and Maria. Homeland Security Operational Analysis Center. Apr. 2019.

[162] U.S. Drought Monitor webpage, National Oceanic and Atmospheric Administration's (NOAA) National Integrated Drought Information System (NIDIS) https://www.drought.gov/drought/snippets/puerto-rico

[163] Drought Conditions in Puerto Rico, USGS webpage - https://www.usgs.gov/centers/car-fl-water/science/drought-conditions-puerto-rico?qt-science_center_objects=0#qt-science_center_objects

dredging was conducted to increase storage capacity (Soler-López and Gómez-Gómez, 2005). However, the reservoir has lost nearly forty percent (40%) of its storage capacity over the 1953 to 2009 period. This loss in storage capacity reduces the ability of the reservoir to store water during wetter times for use in drier times.

Vulnerability to Human-Caused Disaster

As mentioned above, water sector facilities are vulnerable to intentional and un-intentional human caused disaster such as terrorism and construction activity, respectively. The recent pipeline break of the North Coast Super-aqueduct that runs from Rio Grande de Arecibo to San Juan resulted from contractor excavation activities and caused catastrophic damage to the adjacent highway, as well as water service disruptions. Water sector facilities are also vulnerable to terrorism and are specially designated critical infrastructure facilities by the Department of Homeland Security and subject to requirements under the Cybersecurity and Infrastructure Security Agency.

Water and Wastewater Risk Analysis

Based on the results of the PRDOH Risk Assessment, the map below displays water and wastewater sector infrastructure in relation to medium-to-high-risk areas. The determination of risk is based on the composite risk scores which range from: Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); and High (200 or more).

A total of 9,226.81 miles (or forty-four percent (44%)) of water and wastewater line segments are located in Medium, Medium High, and High-risk areas. [164] Approximately twenty-two percent (22%) of water and wastewater facilities are in one (1) of the three (3) high-h risk areas. These facilities include approximately:

- twenty-two percent (22%) of raw water facilities,
- fifteen percent (15%) of drinking water facilities,
- fifty-eight percent (58%) of sewage facilities,
- seventy-one percent (71%) of storage facilities,
- seventy-two percent (72%) of maintenance facilities,
- one hundred percent (100%) of laboratories,
- eighty-five percent (85%) of administrative offices, and
- ninety-two percent (92%) of commercial offices.

[164] Composite risk scores range from Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); High (200 or more)

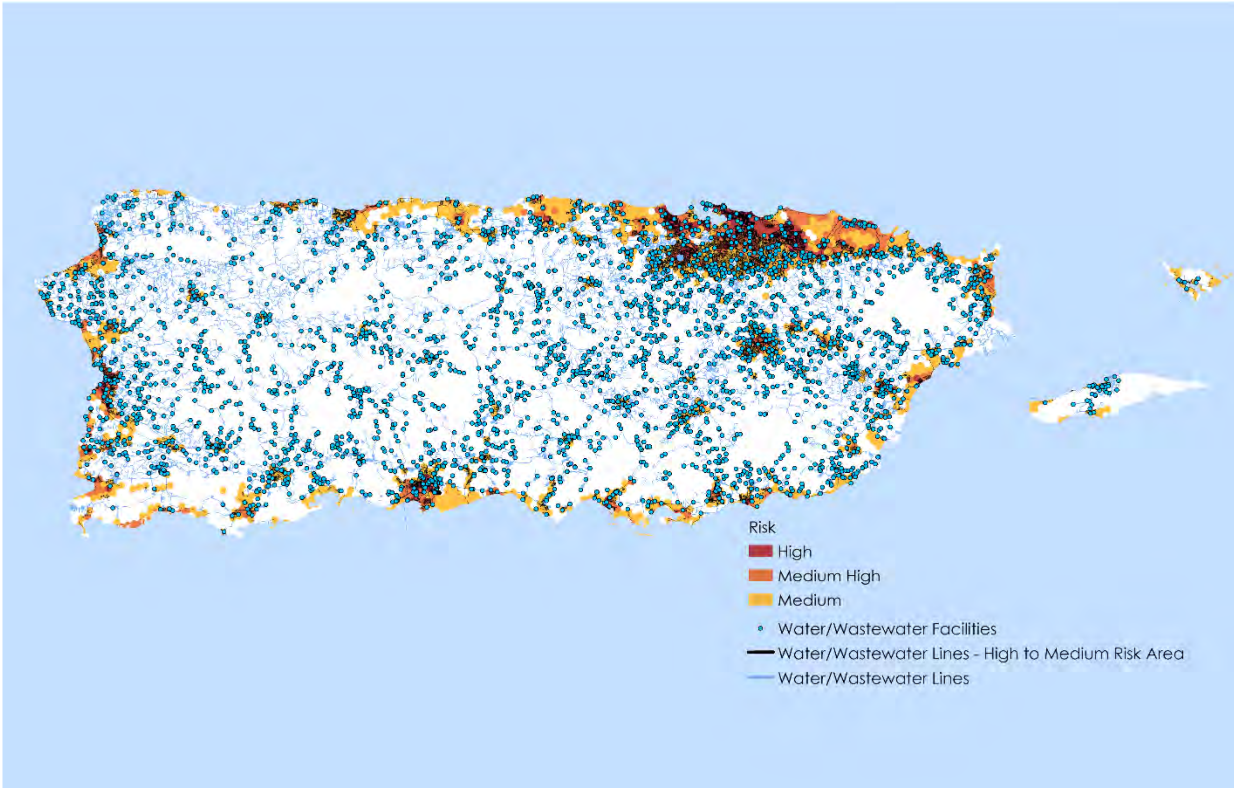

Figure 68. Water and Wastewater Facilities and Proximity to Risk Areas Classified as High, Medium High, or Medium

Water and Wastewater Facilities in Risk Areas Classified as High, Medium High, or Medium [165]

Type of Water/Wastewater Facility	Risk	Total Water/Wastewater Facilities	Percent of Total Facilities
Raw Water	HIGH	1	
	MEDIUM HIGH	3	
	MEDIUM	11	
	Total	**15**	**21.74%**
Drinking Water	HIGH	20	
	MEDIUM HIGH	77	
	MEDIUM	393	
	Total	**490**	**15.47%**
Sewerage	HIGH	78	
	MEDIUM HIGH	168	
	MEDIUM	346	
	Total	**592**	**58.15%**
Storage	HIGH	3	
	MEDIUM HIGH	6	
	MEDIUM	8	

165 Composite risk scores range from Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); High (200 or more)

Water and Wastewater Facilities in Risk Areas Classified as High, Medium High, or Medium[165]			
Type of Water/Wastewater Facility	Risk	Total Water/Wastewater Facilities	Percent of Total Facilities
	Total	**17**	**70.83%**
Maintenance Facilities	HIGH	4	
	MEDIUM HIGH	3	
	MEDIUM	6	
	Total	**13**	**72.22%**
Laboratory	HIGH	2	
	MEDIUM	1	
	Total	**3**	**100.00%**
Administration Offices	HIGH	4	
	MEDIUM HIGH	3	
	MEDIUM	4	
	Total	**11**	**84.62%**
Commercial Office	HIGH	5	
	MEDIUM HIGH	7	
	Total	**12**	**92.31%**
Grand Total		**1153**	**26.66%**

Water and Wastewater Line Segments in Risk Areas Classified as High, Medium High, or Medium[166]		
Risk	Total Water and Wastewater Line Segments (Miles)	Percent of Total Line Segments
HIGH	2,646.49	12.79%
MEDIUM HIGH	1,809.74	23.06%
MEDIUM	4,770.58	8.75%
Total	**9,226.81**	**44.61%**

[166] Composite risk scores range from Low (0-50); Medium Low (50.1 – 100); Medium (100.1 – 150); Medium High (150.1 – 200); High (200 or more)

RISK-BASED MITIGATION NEEDS ASSESSMENT

RISK-BASED MITIGATION NEEDS ASSESSMENT

The methodology for determining risk-based mitigation needs for the citizens of Puerto Rico considers several interrelated factors and characteristics of the Puerto Rico system. Using the lifeline construct, PRDOH has identified the greatest needs within each of the critical and secondary lifelines by evaluating contributors and mitigators of instability in four key pillars: (1) local planning and regulations, (2) structure and infrastructure improvement needs, (3) natural systems protection, and (4) education and awareness.

Through the Hazard and Risk Analyses and the analysis of lifeline assets and stakeholder input, PRDOH has identified both contributors to instability, as well as existing and potential mitigators of instability in a disaster event. Instability is the tendency to be highly impacted by a disturbance or hazardous event. The goal of mitigation is to reduce instability and move Puerto Rico into a more resilient state.

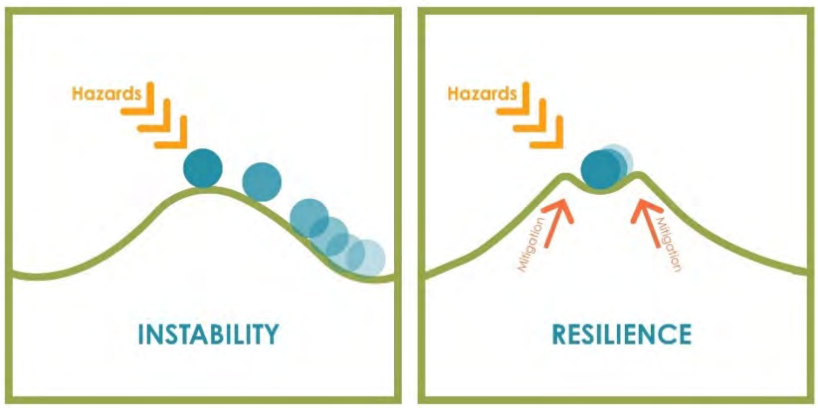

Figure 69. Illustration of the trajectory of a system threatened by instability and a system cushioned by resilience

True mitigation reduces risk to people, lifelines, buildings, infrastructure, ecosystems, and cultural, historic, and natural resources. Mitigation promotes the reduction in risks to critical infrastructure by evaluating potential threats, encouraging resiliency in infrastructure, and planning for redundancy in lifeline services. Each lifeline depends on multiple infrastructure sectors, businesses, and supply chains to function.

PRDOH has determined that infrastructure within each of the seven (7) lifelines could benefit from modernization and investment in retrofits to meet requirements of the latest International Building Code 2018 requirements adopted by the Government of Puerto Rico in November 2018.

New construction that incorporates self-sustaining systems lessens the dependence on fragile centralized systems, thereby promoting resilience. Built-in redundancy and utilization of green infrastructure is key. Improved coordination and governance between institutions, regional problem-solving collaboration, and systems that improve digital data collection, sharing and dissemination are essential in this endeavor.

LIFELINE MITIGATION AND STRENGTHENING NEEDS

Strengthening of lifeline infrastructure, when supported by eco-conscious policy reform, green infrastructure, and whole community coordination, can have transformative effects. In Puerto Rico, where climate sensitive events and other natural, and human-caused, hazards are common-- even cyclical--, human activity must adapt. Puerto Rico currently faces a disparity between mitigation project needs and available assistance funds. This risk-based needs assessment, therefore, considers the most critical, transformative, and essential lifeline strengthening needs that serve multi-risk mitigation in the priority lifelines subsectors shown below.

Figure 70. Illustration of critical lifeline sectors

The chart in the following pages profiles the observed contributors and mitigators of instability within the complex Island-wide system encompassing critical and secondary lifeline analysis.

Contributors and Mitigators of Instability for:
All Lifelines

	Contributors	Mitigators
Local Planning and Regulation	• Adherence to building code requirements is cost prohibitive for many households and property owners. • Maritime trade and shipping requirements imposed by the Jones Act drive up costs for Puerto Rico's import/export economy. • Ownership of public assets, including critical lifeline assets (ex: road networks, public buildings, schools) is undefined, thus maintenance and upkeep is unclear and, as a result, infrastructure quality suffers. • Lack of alignment between long-term plans and implementation can lead to lack of continuity. For example, PREPA's IRP includes an increase in renewable energy but the plan being advanced emphasizes creates mini-grids dependent on liquid natural gas.	• Support data-driven decision making by providing updated and transparent data collection that complements the cadastral database being built through the GeoSpatial Frame program.[167]. • Leverage federal and state level research as launching pad for mitigation investment decisions. • Minimize displacement of homeowners and vulnerable communities through regional, strategic, and multi-sector mitigation planning. • Build capacity for local entities, municipalities and regional partnerships to gain access to mitigation assistance through refined mitigation planning. • Support modernization of land use, code compliance, and governance structures that support mitigation. • Leverage existing funding opportunities to support long term operations, maintenance, and staffing of programs and projects. • Create long-term planning and grant fund opportunities by supporting the establishment of Economic Development Districts (**EDD**).
Structure and Infrastructure	• All lifelines have dependence on the Energy lifeline. In Puerto Rico, energy infrastructure is, on average, about 30 years older than anywhere else in United States and its design makes it vulnerable to impacts of natural disasters. • The utilities infrastructure is poorly maintained and deteriorated. For example,: forty to sixty percent (40%-60%) of water in the water system is lost from leakage and theft. • Communities that are disconnected from centralized system have been left out of the mitigation planning process. Non-emergency communications systems cannot function when Energy lifeline is down. • Hurricanes Irma and María caused overload in systems and also reduced capacity in others (ex: solid waste infrastructure lost two (2) years of capacity due to debris, erosion caused high deposits of sediments in water reservoirs). • Lifeline facilities require modernization including self-sustaining infrastructure, redundant systems, and equipment to continue operations during and after a disaster event.	• Incorporate self-sustaining infrastructure alternatives that include green infrastructure and nature-based solutions to address and mitigate hazards. • Provide assistance, data, mapping, and capacity building for rural areas disconnected from centralized system. • Focus on systems redundancy, independence and regional solutions to lifeline infrastructure and services' needs. • Learn from best practices from Puerto Rico and equivalent jurisdictions that showed reliability, resilience and true hazard mitigation during recent disasters. • Infrastructure built to updated construction standards proved to withstand recent hurricane impacts. • Consider advanced technologies that take into account the state of current systems and prove beneficial through a cost benefit analysis. • Take advantage of current population trends to focus on the hardening of existing infrastructure and redevelopment of land instead of the expansion of lines and networks that could promote increased urban sprawl.

[167] The Puerto Rico Geospatial Frame Program is a recovery program funded by the PRDOH CDBG-DR grant to create an improved parcel registry system.

Contributors and Mitigators of Instability for:
All Lifelines

	Contributors	Mitigators
Natural Environment	• High risk for climate-sensitive weather events of catastrophic scale. Coastal communities face threatening climate-sensitive weather hazards and sea level rise. • Power is derived from ninety-eight percent (98%) imported fossil fuels (petroleum fuel, natural gas, and coal) and backup generators are also fuel dependent. • Puerto Rico contains certain soil types and mountainous terrain that pose high risk of landslide that can cause lifeline systems to fail or collapse, loss of life and property. • Inadequate planning for the unique needs of Karst regions. Flood-mitigation practices that result in extreme conveyance of water runoff can impact downstream populations (such as channelization without consideration of upstream or downstream impact).	• Incorporate sustainable practices like cleaner energy solutions that harness the climate and biophysical attributes of the Island such as wave energy, wind, and solar. • Allow for biophysical conditions to inform planning for human activity on the Island. • Study and understand natural systems, such as streams and watersheds, to achieve flood and other hazards mitigation. For example, taking into account the incorporation of smart stream technology or natural steam design in a way that can limit impact to downstream populations without altering the current system. • Focus on ecosystem services provided by natural coastal systems that increase resilience and protect from future hazards (ex: wetlands, mangroves, dunes). • Organics waste and vegetative debris require refocus on management. Hardwoods, composting materials, and other economically viable solutions exist in materials currently considered as waste and debris.
Education and Awareness	• Puerto Rico has more than 130 agencies, which is both costly and creates a siloed and complex bureaucracy. • Outdated and obsolete regulations may unnecessarily curtail economic growth and impede private sector investment. • Municipalities lack funding for infrastructure maintenance at the local level and to fulfill staffing needs. • Insufficient workforce to support public education in terms of mitigation, community health support, and green infrastructure practices.	• Capitalize on public interest in moving toward an increase in renewable energy. • Educate the public on how to take advantage of programs that will attract private investment in development projects that can also complement and leverage the use of federal funds. • Increase stakeholder engagement to communicate common understanding of risk and gather local insight for solutions.

Transportation Lifeline Needs

Contributors and mitigations of instability within the Transportation lifeline identify a need to overcome the challenges of aging infrastructure and inform interagency and partnership investments in strengthening critical supply routes that can become resilience corridors.

Contributors and Mitigators of Instability for:
Transportation Lifeline

	Contributors	Mitigators
Local Planning and Regulation	• Ownership of road networks for maintenance and upkeep is not always clear for tertiary and municipal systems, and road quality suffers. • Federal transportation aid provided to Puerto Rico is not determined by the standard formula apportionment (which applies to states), but instead by a fixed term allocation. With a fixed allocation (rather than a formula-based apportionment) it is extremely difficult to predict the future level of funding beyond the current commitments. • Efforts to consolidate and reorganize multiple transportation authorities through recent laws have not met coordination goals.	• Puerto Rico Department of Transportation has plan review authority over federal and state highways, promoting higher quality, and construction of federally classified assets. • Federal Highway funding supports better road conditions for main highways under FHWA. • P3 plan to increase number of toll roads on a 25-year timeline supports move toward resilient infrastructure. • In a disaster, toll road fees are suspended. • Support data-driven decision making by providing updated and transparent data collection. • Utilize the Statewide Transportation Improvement Program (STIP), 2046 Long Range Transportation Plan, and 2028 Puerto Rico Transportation Asset Management Plan to inform investment.
Structure and Infrastructure	• Tertiary roadways connecting to neighborhoods universally failed. None of the tertiary roadway considered in the DTPW assessment was fully functioning one month after Hurricane María. • Only sixty-five percent (65%) of interstate, primary, and secondary roadways was open one (1) month after Hurricane María. • Secondary and tertiary road systems lack sufficient annual funding for necessary repairs and maintenance. Municipality-owned roads in the tertiary system have been the least resilient in recent disaster events. • Ninety percent of intelligent traffic management system was damaged after the hurricanes. • In 2016, ninety-nine percent (99%) of all foreign throughputs passed through three (3) ports with Port of San Juan receiving the majority. The Port of San Juan was identified by the DHS Interdependency Assessment as a single point of failure for the delivery of nearly every product sent or received by Puerto Rico. • Fragile and congested roads that provide ingress/egress leave communities vulnerable.	• Fund, restore, and build on an intelligent traffic management system using promised Federal Highway grant money. Ninety-six percent (96%) of freeways remained open after hurricane events due to construction standards in place. • Port of the Americas Authority plans are currently underway to develop the Port of Ponce to serve as a transshipment hub to increase resiliency and redundancy.

Contributors and Mitigators of Instability for:
Transportation Lifeline

	Contributors	Mitigators
Natural Environment	• It is difficult to preserving some types of terrain when developing roads because of the varying soil stability/liquefaction, elevation and other factors. • Geographic isolation of the Island means response personnel and supplies could be delayed (by 6 days by boat) by disrupted supply chains. • Grey infrastructure inhibits ecological conveyance of watershed.	• Tree-lined streets increase viability of modes of transportation such as cycling and walking. Tree maintenance around pedestrian and bicycle lanes is crucial to allow for safety and accessibility after a disaster event.
Education and Awareness	• Language barriers can increase difficulty for accessing and completing programs. • There is a preference for personal vehicle usage and a cultural stigma around use of public transportation systems, or alternative transportation modes (such as bicycling, walking, carpooling, or other).	• Community-based social networks pulled together to remove debris quickly after hurricanes. Such social systems prove supporting in response efforts. • Build capacity for municipalities and regional partnerships to gain access to mitigation assistance through multiple grant programs. • Increase stakeholder engagement to communicate common understanding of risk and gather local insight for solutions.

Resilient Corridors for Circulation and Supply Chain Continuity

PRDOH recognizes that within the main mode of transportation for the Island – the road network – there exist critical corridors that connect communities in Puerto Rico to critical ingress/egress routes and necessary supply chain circulation. These corridors are Puerto Ricans' main connection to their work, food, healthcare, community, and the ports and airports. They are the routes by which supplies are moved around the Island, including food, fuel, and medicine. Though many main highways in the primary road system were intact following the hurricanes, many internal roads of the secondary and especially the municipally-owned tertiary systems were closed, limiting citizens' access to everything from fresh drinking water to medical assistance.

An extreme event, such as the 2017 Hurricanes Irma and María, can disrupt a supply chain in three (3) primary ways.[168]:

1. ***Demand shift***: A hurricane can distort demand patterns before and after the storm. Demand for gasoline, generators, batteries, and food items often spikes before a hurricane, while demand for bottled water, chainsaws, garbage cans,

[168] Strengthening Post-hurricane Supply Chain Resilience, Observations from Hurricanes Harvey, Irma and Maria, Page 21. (2020) (https://www.nap.edu/read/25490/chapter/4#21)

tarps, and other recovery supplies are usually elevated afterwards. Such demand spikes can push utilization of bottlenecks above one hundred percent (100%), even if only some parts of the supply chain are disrupted by the storm.

2. ***Capacity reduction*:** Examples of capacity reductions that occur in the wake of a hurricane include a production or transportation process that is limited by lack of plant, power, or people: a factory (plant) unable to produce due to physical damage, a retail outlet unable to store perishable products due to lack of electricity (power), trucks unable to deliver goods for lack of drivers (people). Each of these instances was a factor following the 2017 hurricanes in Puerto Rico.
3. ***Communication disruption*:** A hurricane can interrupt the normal channels by which information is communicated up the supply chain. For example, normal operations of a supply chain can be impeded by power or cell phone outages, broadband interruptions, point-of-sale system failures, and absence of key individuals. Furthermore, the exceptional relief supply chains established to deliver essential products in the wake of a hurricane lack the sophisticated communication systems utilized in many commercial supply chains, and therefore, struggle to match supplies with demand.

Investing in Resilient Corridors

CDBG-MIT funding should prioritize mitigation of risk to key lifeline assets that when stabilized in a disaster event, contribute to the Island's resilience. Transportation assets, including points of entry at airports and seaports and connecting road networks, are essential for movement of people and goods throughout the Islands of Puerto Rico before, during, and after a disaster event. The map on the following page shows the Freeways (freeway and/or expressway), primary roadways (interstate and primary arterials), secondary roadways, and tertiary roadways in Puerto Rico. The Freeways and primary roadways are responsible for the movement of the majority of the population in Puerto Rico as well as freight on a daily basis. The secondary, tertiary, and municipal (not shown) Roadways provide access to neighborhoods, residences, and community assets.

Figure 71. Puerto Rico State Roadway Network

The Puerto Rico Department of Transportation and Public Works (**DTPW**) completed an assessment of the roadway network on October the 24th, 2017. The map on the following page shows the status of the roadways, excluding tertiary and municipal, assessed as part of that DTPW assessment.

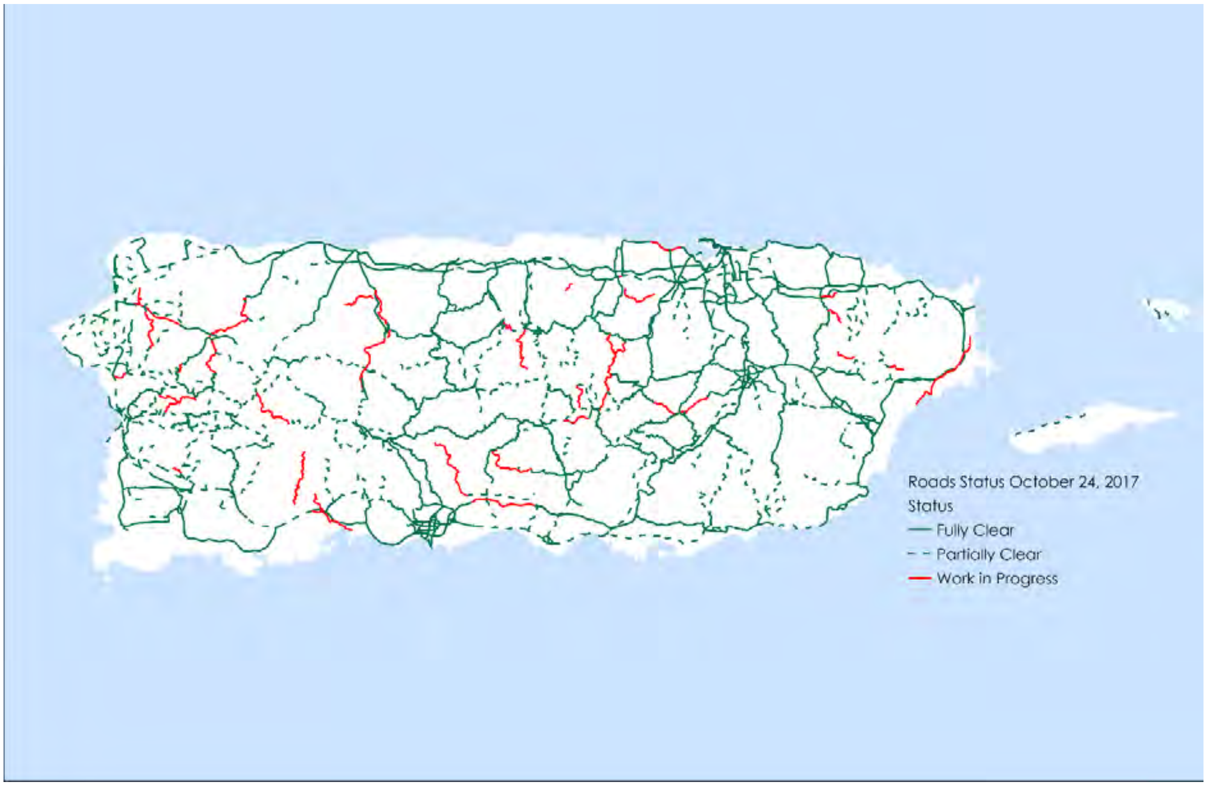

Figure 72. Puerto Rico Freeway, Primary, and Secondary Roadway Status (DR-4336 and DR-4339 - October 24, 2017 Assessment)

The DTPW assessment determined that, just over a month after the 2017 hurricanes, approximately ninety-six percent (96%) of the freeway system was fully clear and functioning at full capacity. Just under sixty-four percent (64%) of the Primary and Secondary Roadways were open and functioning at full capacity and none of the Tertiary Roadways were fully open and/or functioning at full capacity. The table below shows the roadway status, 2,393 KM of roadway fully clear, 2,088 KM of roadway partially clear, 330 KM of roadway with work in progress, 8,295 KM totals, and percent of roadway open.

Status of Primary, Secondary, and Tertiary Routes (DR-4336 and DR-4339 - October 24, 2017 Assessment)					
Roadway Class	**Fully Clear (KM)**	**Partially Clear (KM)**	**Work in Progress (KM)**	**Total (KM)**	**Percent Fully Functional (%)**
Freeway	557.01		25.66	582.68	**95.60%**
Primary Route	740.95	389.59	27.98	1,158.52	**63.96%**
Secondary Route	1,095.14	515.88	102.21	1,713.23	**63.92%**
Tertiary Route		793.98	174.15	4,840.93	**0%**

The DTPW assessment identifies a very high level of resilience for the Freeway network and moderate resilience for the Primary and Secondary roadways. Approximately seventy percent (70%) of the population of Puerto Rico reside within five (5) miles of a resilient freeway. However, tertiary roadways are highly susceptible to damage from hurricane events. The remaining thirty percent (30%) of the population in Puerto Rico do not have sufficient access to a resilient roadway. Many of these people were trapped because roads had been washed out or buried under landslides. Without access to food, water, fuel, or help and without power or communication systems working their circumstances were desperate. The map below shows populations with a density greater than 500 people every one-half mile and their proximity to the freeway network.

Figure 73. Puerto Rico Population Proximal to Resilient Freeways

Prioritization of CDBG-MIT funding to develop a more extensive resilient roadway network

The *Resilient Freeways and Expressways* table on the following page identifies the Freeways and expressways in Puerto Rico. These roadways proved resilient after the 2017 hurricanes. These roadways also serve approximately seventy percent (70%) of Puerto Rico's population. The freeways in Puerto Rico proved very resilient, approximately ninety-six percent (96%) opened one (1) month after the 2017 hurricanes. Because these roadways serve seventy (70%) of the population, CDBG-MIT dollars that harden, make more resilient, or mitigate risk to the segments within these roadway systems that did not withstand recent hazards, will mitigate risk for the majority of Puerto Rico's population.

Resilient Freeways and Expressways		
PR-5	PR-52	PR-54
PR-22	PR-53	PR-66

The Interstate, Primary and Secondary Roadways proved to be much less resilient than the Freeway system. Only approximately sixty-four percent (64%) were open one (1) month after the 2017 hurricanes. They are also the only long-range transportation alternatives for at least thirty percent (30%) of Puerto Rico's population. CDBG-MIT dollars should prioritize transportation projects that build new roadways or enhance the Interstate, Primary and Secondary Roadways of Puerto Rico to ensure an Island-wide interconnected resilient roadway network. The *Interstate and Primary Roadways* table below identifies the Interstate and Primary Roadways in Puerto Rico which follow a two-digit numbering system and the *Secondary Roadways* table identifies the Secondary Roadways of Puerto Rico which follow a three digit numbering system.

Interstate and Primary Roadways			
PR-6	PR-20	PR-37	PR-28
PR-8	PR-23	PR-38	PR-31
PR-9	PR-24	PR-39	PR-1
PR-10	PR-26	PR-40	PR-2
PR-12	PR-27	PR-41	PR-3
PR-14	PR-29	PR-42	PR-25
PR-15	PR-30	PR-47	PR-21
PR-16	PR-32	PR-60	PR-34
PR-17	PR-33	PR-63	PR-1P
PR-18	PR-35	PR-64	
PR-19	PR-36	PR-65	

Table 1: Secondary Roadways

Secondary Roadways			
PR-100	PR-131	PR-163	PR-193
PR-101	PR-132	PR-164	PR-194
PR-104	PR-133	PR-166	PR-195
PR-105	PR-134	PR-168	PR-196
PR-106	PR-136	PR-169	PR-198
PR-107	PR-137	PR-170	PR-199
PR-108	PR-138	PR-171	PR-165
PR-109	PR-139	PR-172	PR-112
PR-110	PR-140	PR-173	PR-103
PR-111	PR-141	PR-174	PR-145
PR-113	PR-142	PR-175	PR-183
PR-114	PR-143	PR-176	PR-191
PR-115	PR-144	PR-177	PR-102
PR-116	PR-146	PR-178	PR-156
PR-117	PR-149	PR-179	PR-181
PR-118	PR-150	PR-180	PR-167
PR-119	PR-151	PR-182	PR-148
PR-121	PR-153	PR-184	PR-120
PR-122	PR-154	PR-185	PR-124
PR-123	PR-155	PR-186	PR-135
PR-125	PR-157	PR-187	PR-152
PR-127	PR-159	PR-188	
PR-128	PR-160	PR-189	
PR-129	PR-161	PR-190	
PR-130	PR-162	PR-192	

Energy Lifeline Needs

Because all other lifelines depend on a reliable power supply to function, power is likely the most important lifeline on the Island; yet it remains the most vulnerable. Contributors and mitigators of instability in the Energy lifeline focus on the need for innovation, cost-reducing strategies, and investment in redundancy through community, building and home installations of renewable energy infrastructure.

Contributors and Mitigators of Instability for:
Energy Lifeline

	Contributors	Mitigators
Local Planning and Regulation	• Power generation and distribution are provided by a centralized system in Puerto Rico which remains vulnerable to widespread outage. • Lack of competition inhibits innovation. • PREPA began bankruptcy proceedings in July 2017 – and efforts to restructure PREPA debt under PROMESA are ongoing to resolve structural issues. • PREPA's Integrated Resource Plan (IRP) includes an increase in renewable energy, however the plan being advanced creates mini-grids dependent on liquid natural gas which is subject to the same issues as fuel oil. • High costs and permitting delays disincentivize localized renewable energy solutions that tie into the grid. • Historically there has been disconnection between legislation passed by the Governors of Puerto Rico and planning and implementation by the public corporation PREPA. PREPA's adoption of the reform in Act 17, 2019, Puerto Rico Energy Public Policy, 29 L.P.R.A. § 1141 is uncertain. • The electrical system is highly polluting as a result of poor energy diversification and high fossil fuel dependency. LNG produces less particular pollution than coal or diesel but produces equally threatening greenhouse gas emissions. • Purchase of home solar systems and battery storage is cost prohibitive for most households.	• The Government of Puerto Rico set a goal of 100% renewables by 2050 by enacting Act No. 17 of April 11, 2019 as amended, 29 L.P.R.A. § 1141, et seq; known as Puerto Rico Energy Public Policy Act • Act No. 57 of May 27, 2014, as amended, 22 L.P.R.A .§ 1051 et seq; known as The Puerto Rico Energy Transformation and Relief Act mandates the phasing out of coal-fired electricity generation by 2028. • The Puerto Rico Energy Bureau (PREB) has been created by Act No. 57 of May 27, 2014, as amended, as a regulating body to serve as key component for the full and transparent implementation of the Energy Reform. Specifically, the PREB has the responsibility to regulate, monitor and enforce the energy public policy of the Government of Puerto Rico. • Create long-term planning and grant fund opportunities by supporting the establishment of Economic Development Districts (EDD).

Contributors and Mitigators of Instability for:
Energy Lifeline

	Contributors	Mitigators
Structure and Infrastructure	• Power grid system is old, poorly maintained and 80% of the transmission and distribution lines were knocked down by the hurricanes in 2017. • Vertically integrated power systems mean a failed transmission line in one area leads to power outages for miles around. • Power is created primarily in the south and transported to the largest population, in the north, through vulnerable transmission lines stretched across the Island's interior. • Power grid system is heavily dependent on imported fossil fuels which are expensive, polluting, and totally dependent on complex supply chains for delivery. • Fuel costs comprise roughly 70% of PREPAs operating costs. • Backup power sources are emergency generators which are themselves dependent on fossil fuels and vulnerable to crashes and outages. • Fuels, including the liquefied natural gas (LNG) PREPA proposes making its key power fuel, are very costly and the IRP predicts prices will rise. Puerto Ricans already pay more for electricity than anyone on the mainland. • New LNG infrastructure and long-term supply contracts make Puerto Rico energy dependent on fossil fuel commodities for decades to come. • Due to lack of regulatory clarity, the current 2% of renewable energy infrastructure is unable to capitalize on the opportunity for a hybrid of renewables based on the resources of the Island. • Puerto Rico's 20 hydroelectric generating units, some of which are more than 100 years old, are sited on reservoirs that often supply drinking and irrigation water as well as electricity.	• Residents have already begun to build microgrids with the help of grants and corporate gifts. Microgrids ensure that power going out in one area, will not bring down power in adjacent areas. • There is a growth in the deployment of solar panels and batteries which proved more resilient through the hurricanes. • Renewable power sources such as wind and solar do not rely on vulnerable supply chains. • The cost of installing renewable energy sources may be the same or less than the cost of replacing the fragile grid, but with renewables, the cost of the energy after installation is negligible while the cost of LNG is significant. • Studies have shown Puerto Rico to be a good location for ocean energy systems. • Cogeneration and trigeneration technology integrated into critical infrastructure lessens the demand on the grid and increases the energy security and resilience of the facility. • Redundant systems established before the storms proved to be lifesaving by maintaining sufficient power to refrigerate medication and power equipment.
Natural Environment	• A little over 275 miles 21% of power transmission lines are located in medium to high risk area. Approximately thirty- eight percent (38%) of power generation facilities are in a medium to high risk area.	• The Puerto Rico climate is favorable for the production of wind, solar, wave, and ocean geothermal renewable energy. • Puerto Rico's topography and abundant rainfall can be stored in reservoirs and utilized for hydroelectric power.

Contributors and Mitigators of Instability for: Energy Lifeline	Contributors	Mitigators
Education and Awareness	• Puerto Rico lacks the specialized/skilled workforce necessary for hurricane-resistant installation of equipment and long-term maintenance. • There is a lack of public education around system maintenance to support stability of home-based solar system installations.	• Capitalize on public interest in moving toward an increase in renewable energy. • Provide public education and vocational job training to support rapid progress toward Government of Puerto Rico goals for renewable energy and a culture of maintenance. • Partner with Caribbean neighbors on public education to strengthen a regional approach. • Leverage partnerships with non-governmental advocacy entities that further the mission to secure renewable energy for the benefit of Puerto Rican citizens. • Utilize case studies such as Casa Pueblo and Toro Negro as best practice models for sustainable communities. • Build capacity for local entities, municipalities and regional partnerships to gain access to assistance for alternative energy solutions through multiple grant programs. • Increase stakeholder engagement to communicate common understanding of risk and gather local insight for solutions. • Utilize cogeneration case studies such as the Hospital La Concepción, in San Germán, which was able to operate without interruption after the blackout because their electrical system operates independently from PREPA. It is a combined heat and power generation system (known as CHP), that operates with propane gas and has minimal emissions.

Due to the extensive damage the power grid sustained from the 2017 Hurricanes, HUD will make a separate allocation of $1.93B for power grid repairs under a separate Federal Register notice and has prohibited the use of CDBG-MIT funds for electrical system improvements or risk mitigation until the notice is released.[169]

Consequently, the programs under this Action Plan encourage localized energy resilience measures across all economic sectors prior to HUD's publishing of the separate Federal Register notice for the $1.93 Billion, and major electrical system risk mitigation efforts afterwards.

Acknowledging the longer-term timeline on a comprehensive power system overhaul, assisting consumers with renewable energy systems, like solar, can provide redundancy and energy access while also supporting resiliency goals. Most renewable generating facilities survived Hurricane María with modest amounts of damage, except two (2)

[169] United States, Department of Housing and Urban Development, "Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees; Commonwealth of Puerto Rico Allocation." 85 Fed. Reg. 4676. (January 27, 2020)

facilities on Puerto Rico's east coast where the eye of the storm came ashore. The Island's other renewable facilities were able to fully re-connect to the grid in early 2018.[170]

Alternative Energy and Renewables

The United States Government federalized the electric power system's recovery process and delegated it to the USACE, to the extent that it had the final say in all.

The Financial Oversight and Management Board 2018 fiscal plan[171] for PREPA explained that the utility must be completely overhauled:

> "PREPA must change drastically. PREPA's power generation infrastructure is aging and inefficient. The transmission and distribution grid are fragile and severely storm damaged. Operations are inefficient and unresponsive. Electricity is provided at a high cost and is unreliable. Debt proceeds were used to subsidize shortcomings instead of used to invest in modernization. Responses to Hurricanes Irma and María fell far short of what customers expected and deserved. Summed together, it is clear that Puerto Rico needs a comprehensive power sector transformation."

The Opportunity in Renewable Energy

True renewable resources that are available to Puerto Rico include solar with photovoltaic storage, ocean energy, offshore and onshore wind, and hydroelectric power. Possible additions would be wave energy and biofuels. The advantage of renewables is that while they—like the existing PREPA grid—would require significant investment upfront, they would not have the exorbitant cost of purchasing and importing fuel for those power systems, year after year.

Investment in renewable energy development could create stability not only in terms of reliable energy, but also jobs and environmental factors. Puerto Rico is already considering some of these options. One project being considered, called Puerto Rican Ocean Technology Complex (**PROTECH**), would create a research and development park to study ocean technologies including ocean energy. It would include private-public partnerships and academic involvement. One of its main programs would be ocean thermal energy conversion (**OTEC**) and sea water air conditioning (**SWAC**) systems. The byproducts of those systems can contribute to production of bottled water, cosmetics, aquaculture, leisure medical treatments and food components.[172]

Solar

There has been a growth in solar power, especially since Hurricane María. As many as 12,000 Puerto Ricans had installed solar power and formed micro-grids prior to Hurricanes Irma and María and at least 10,000 more in the year following.

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[170] "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." Puerto Rico - Territory Energy Profile Analysis - U.S. Energy Information Administration (EIA), 21 Nov. 2019, www.eia.gov/state/analysis.php?sid=RQ

[171] https://www.documentcloud.org/documents/5026063-PREPA-Fiscal-Plan-8-1-18.html

[172] Government of Puerto Rico Department of Economic Development and Commerce, Puerto Rican Ocean Technology Complex Proposed Roadmap for Development, February 20, 2020

As described in the Energy lifeline analysis, examples of communities in Puerto Rico that have formed micro-grids of distributed power are available. A virtual grid or smart control system routes power to where it is needed in the community. In some communities, these micro-grids can connect to and disconnect from the larger grid to share excess power and switch to grid power when necessary. If the main grid goes down, the community grid disconnects, and their power is protected.

Estimates for solar costs can be found on sites like Solar-estimate:

> "As of May 2020, the average cost of solar panels per watt in Puerto Rico is $3.98/watt. A typical 6000 watt (6 kW) solar system is $23,882 before the federal solar credit and $17,673 after claiming the federal solar tax credit."

The cost of solar energy is currently about 0.06 cents per kilowatt-hour and expected to go to 0.03 percent in the near future. Currently Puerto Ricans are paying nearly 0.18 cents per kilowatt-hour and the PREPA IRP predicts that cost will rise.

Hydropower

Puerto Rico has twenty (20) hydroelectric plants which all date back to the 19th century.[173] PREPA's seven (7) hydro facilities have an available capacity of approximately 60 MW, depending on operating conditions. The largest hydro plant is Dos Bocas, a 22.5 MW facility. Others include Rio Blanco (5 MW), Yauco 2 (9 MW), Toro Negro I and II (10 MW), Garzas I and II (12 MW), Caonillas (4 MW), and Patillas (1.4 MW). Further investigation on the cost to make these plants operational could prove beneficial, since the cost of electricity from hydropower is generally low.[174] Some groups, including Harvard's "Climate Conditions Living Lab", are working on plans to revitalize[175] some of Puerto Rico's hydroelectric plants.

Following the 2017 hurricanes, there was extensive damage[176] to the Dos Bocas plant including intrusion of significant amounts of mud and water, as well as damage to the Westinghouse unit due to a ground fault on the stator. As of November 29, 2017, Yauco 2 and Toro Negro were in service.

Toro Negro is working to become independent of the grid by increasing its solar power and transferring operation of the Toro Negro hydro plant to the community.[177] This may be a model for the rest of the Island.

[173] Puerto Rico Electric Power Authority. Accessed at: https://aeepr.com/en-us/QuienesSomos/Pages/History.aspx
[174] International Renewable Energy Agency, Renewable Energy Technologies Cost Analysis Series, June 2012.
[175] Mason, Edward. "Harvard Students Create Plan for Renewable Electricity in Puerto Rico." Harvard Gazette, Harvard Gazette, 14 Dec. 2018. Accessed at: https://news.harvard.edu/gazette/story/2018/12/harvard-students-create-plan-for-renewable-electricity-in-puerto-rico/
[176] Governor of Puerto Rico, Build Back Better Puerto Rico: Request for Federal Assistance for Disaster Recovery, 2017.
[177] Velez, Eva Lorenz. "Puerto Rico Senate-Passed Bill Would Transfer Hydroelectric Plant Operation to Town." Caribbean Business, 7 Nov. 2018, www.caribbeanbusiness.com/puerto-rico-senate-passed-bill-would-transfer-hydroelectric-plant-operation-to-town/?cn-reloaded=1

Wind Energy

Puerto Rico has two (2) large wind farms. After Hurricane María, Punta Lima was severely damaged. The other, the Santa Isabel wind farm, was ready to go after about a week. But according to owners, PREPA sharply curtailed their energy generation.[178]

As mentioned in the Hazards report, Puerto Rico lacks the technology to collect accurate wind data. Data from the National Renewable Energy Lab indicates that Puerto Rico is not a feasible site for wind energy, according to one (1) report. But current operators dispute this assertion as a political effort to curtail wind power proliferation:

> "Based on actual data from wind farm developers in Puerto Rico, average annual wind speeds for the two wind farms are approximately 6-6.5 meters per second (m/s); however, the NREL map would suggest these sites are undevelopable."

In 2019, the Resident Commissioner of Puerto Rico introduced a bill to study offshore wind for the Island.[179] The offshore wind market has grown an average of thirty percent (30%) per year since 2010, and new technology has made it increasingly cost effective.[180]

Wave Energy

An emerging source of renewable energy is ocean wave energy. While this is still a nascent technology, a growing number of countries are experimenting with various technologies. The theoretical electrical output of wave energy would be 125% of the world's consumption. Wave energy technologies produce no CO2 and, unlike solar and wind, they produce power twenty-four (24) hours a day, seven (7) days a week, 365 days a year. The potential energy generation from waves in Puerto Rico could be thirty 30 terawatt (TWh) per year.[181]

Biomass

Puerto Rico has traditional biomass resources and could explore the feasibility of importing biomass pellets from the Southeastern US. Another alternative fuel source available locally is Municipal Solid Waste (**MSW**). Most of the twenty-nine (29) landfills in Puerto Rico are beyond capacity, and the US Environmental Protection Agency (**EPA**) has reached agreements to close twelve (12) of them. Each of those agreements include a recycling program, creating the feedstock sorting infrastructure that can facilitate Waste-to-Energy (**W2E**). W2E can reduce the amount of waste headed to a landfill and

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[178] Merchant, Emma Foehringer. "Puerto Rico's Latest Challenge: Utility Curtailment of Wind and Solar Farms." Puerto Rico's Latest Challenge: Utility Curtailment of Wind and Solar Farms | Greentech Media, Greentech Media, 18 May 2018,

[179] "Puerto Rico Congresswoman Introduces Bill to Study Offshore Wind Energy Potential." *Caribbean Business*, 8 Feb. 2019, www.caribbeanbusiness.com/puerto-rico-congresswoman-introduces-bill-to-study-offshore-wind-energy-potential

[180] IEA. "Offshore Wind Outlook 2019 – Analysis." *IEA*, Nov. 2019, www.iea.org/reports/offshore-wind-outlook-2019

[181] Jacobson, Paul T, et al. "Mapping and Assessment of the United States Ocean Wave Energy Resource." *Mapping and Assessment of the United States Ocean Wave Energy Resource (Technical Report) | OSTI.GOV*, 1 Dec. 2011.

generate electricity; an evaluation of W2E in the USVI indicated favorable economics including the cost of limited environmental mitigation.[182]

[182] US Department of Energy, Energy Resilience Solutions for the Puerto Rico Grid. Final Report June 2018. Accessed at: https://www.energy.gov/sites/prod/files/2018/06/f53/DOE%20Report_Energy%20Resilience%20Solutions%20for%20the%20PR%20Grid%20Final%20June%202018.pdf

Communications Lifeline Needs

Contributors and mitigators of instability in the Communications lifeline consider the cross-sectoral roles that public and private entities have in the management of lifeline systems.

Contributors and Mitigators of Instability for:
Communications Lifeline

	Contributors	Mitigators
Local Planning and Regulation	• Law on the Construction, Installation and Location of Telecommunications Towers of Puerto Rico Law No. 89 of June 6, 2000, as amended did not require Category 5 hurricane construction standards to withstand extreme weather event. • In general, Puerto Rico regulation standards for resilience of communications towers/infrastructure were lower than required on the mainland US. • Fiber optic, available in limited metropolitan areas, offers higher speeds but is cost prohibitive for most communities on the Island.	• Portions of the IBC 2018 adopted by Puerto Rico addresses construction standards for communications infrastructure. • Set up EDDs to support regionalization of utilities. • Puerto Rico is building a First Responder Network Authority under the US Dept. of Commerce to build a dedicated, communications "fast lane" for public safety that includes features not available on wireless networks today. • Cell phone providers have agreements in place to allow public entities to use these towers in emergency events. • Support data-driven decision making by providing updated and transparent data collection. • Leverage federal and state level research as launching pad for mitigation investment decisions.
Structure and Infrastructure	• After Hurricanes Irma and María, ninety-five percent (95%) of cellular sites were out of service, ninety-one percent (91%) of private telecommunications infrastructure was damaged, eighty percent (80%) of above-ground fiber optic cable was destroyed. • Communications towers installed before Hurricane María were not built to withstand hurricanes above Category 3. • The Island's main communications system depends on the stability of a vulnerable power system. • Above ground lines are vulnerable to weather events. • Communications systems lack redundancy. • The Recovery Plan indicated that failures in the telecommunications system made it difficult to coordinate both response operations and repair damages to critical systems. Collapse of the telecommunications and widespread infrastructure damage made existing contingency plans insufficient and hindered coordination within state agencies. • e-Remote location of many cell towers complicate repairs and refueling of backup power systems.	• Radio communications remained available after the hurricanes and became a primary method of communication for the Government of Puerto Rico to reach citizens. • Hurricane recovery has prompted private company investments in newer, more resilient technology. • Tie renewable energy into communications towers to prevent prolonged disruptions from power failure. • Educational Broadband system on the Island usually carries a strong signal.

Contributors and Mitigators of Instability for: Communications Lifeline	Contributors	Mitigators
Natural Environment	• Mountainous terrain complicates laying of lines and building of infrastructure to support large geographic (rural) areas. • Vegetation can block lines of sight.	• Puerto Rico's geographic location, although an archipelago, is surrounded by various islands and is relatively near to the US mainland, this allows for continuity in radio communications amid a disaster.
Education and Awareness	• Need for increased capacity in emergency communication systems for quicker response and more reliable data on needs. • Need for increased public education and awareness on tsunami and other early warning alarm systems. • First responders and new hires require continuous training on their agency's updated communications plan and various communication systems installed (radio and satellite) provided as part of the new equipment for emergency response.	• Satellite communications proved effective for organizations like the Puerto Rico Seismic Network, who plan to diversify their communication providers to integrate satellite point-to-point communications to make the network more resilient. • Puerto Rico has the Amateur Radio Emergency Service volunteers (**KP4**) that took an active role during and after the Hurricanes Irma and María. As a result, various agencies have created agreements with KP4, including PREPA. • Community centers like *Fe que Transforma* church in Vieques had dependable communication because the center relied on a KP4 radio communications system equipped with a system that allowed for coordination and logistics with a reach from Florida to Virgin Islands as well as satellite communications system. • Health sector workers have received training on Crisis Emergency Risk Communications.

The Communications sector is a critical lifeline system that is essential to mitigation prior, during, and after the disaster incident. Prior to the disaster, the communications sector can be utilized to issue warnings and guidance of an impending disaster to facilitate public readiness and strategic preparedness activities undertaken at the local level that can minimize injuries and loss of life, especially for vulnerable populations. During and after a disaster, the communications sector is critical to the effectiveness of the overall response efforts by providing the platform for communication and coordination between first responders, governmental agencies, and the public. Functional communications systems during and after a disaster are essential to communicate disaster status, impacts, and needs to enable first responders and authorities to allocate, command, and direct resources to the locations with the most urgent need.

Communication systems also are essential for monitoring and control of industrial, commercial, and utility facility operations, also critical to disaster response or the provision of essential needs and services. There is a critical interdependence between the communications sector and other critical infrastructure lifelines, particularly the electrical and water/wastewater sectors. The Electricity subsector and the Communications sector are highly interconnected. The Communications sector provides key monitoring and control services to the Electricity subsector, while the Electricity subsector provides power that is necessary for Communications sector operations.

Telecommunications and Internet capabilities are also essential to the basic functioning of impacted communities through the interdependence with most of the facilities that comprise the food supply chain, including warehouses and points of sale; from the tracking and delivery of supplies to payment, the communication system is essential to the flow of goods in Puerto Rico.

Recommendations

Operable communications are critical to effective disaster operations. In the aftermath of Hurricane María, with ninety-five percent (95%) of cell towers in Puerto Rico out of service, local, territorial, and federal agencies faced difficulties knowing what was needed and where in the immediate aftermath of the storm. Puerto Rico must ensure survivable communications capability to enable coordination between government leadership and to maintain connection with other critical infrastructure sectors.

With regards to the Communications sector, the programs under this action plan shall facilitate projects that:

1) Increase communication installations resilience to power outages and damage,
2) Leverage available federal, state and local funds (e.g. FCC has allocated approximately $500 million dollars to repair and expand broadband access in Puerto Rico), or,
3) Combine CDBG-MIT funds with and increase the leverage of CDBG-DR funds used to facilitate access to broadband communications, such as broadband ready multifamily housing units.
4) Enhance emergency response communications resilience and survivability to disasters, including utilization of systems, such as satellite communications, that are demonstrably less vulnerable to risk from disasters.

Water and Wastewater Sector Needs

Water and Wastewater lifelines (water sector) are the management, supply, treatment, distribution, and collection network that ensure a community has access to adequate quantities of clean potable water to meet this essential life-giving need and safe, healthful treatment and disposal of sewage necessary to protect public health. The water sector in Puerto Rico can be broadly divided into four (4) subsectors including: water source and supply, drinking water and wastewater, stormwater and flood mitigation, and water resource management systems. Collectively, these systems include the assets necessary for water storage, distribution, conveyance, and treatment as well as the protection of communities and natural ecosystems from flooding and water quality impacts.

Contributors and Mitigators of Instability for:

Water and Wastewater Lifeline Sector

	Contributors	Mitigators
Local Planning and Regulation	• The water quality standards of communities not connected to PRASA centralized systems are unregulated. • The locations of non-PRASA community water systems were not communicated clearly following the hurricanes. • No official coordinating organization organizes and facilitates communications across the 240+ community water systems in Puerto Rico. This resulted in fragmented and varied support from Federal and local entities during response and recovery. • Communities reported a lack of continuity between recovery planning efforts and implemention because of lack of coordination among local governments, federal agencies, private entities and NGOs. • Watershed approach has been widely discussed and recommended, but not implemented. • There are no policies and laws requiring decommissioning or removal of obsolete and decaying dams that fail to meet dam safety standards.	• Support modernization of land use, code compliance, and governance structures that support mitigation • Support data-driven decision making by providing updated and transparent data collection. • Set up Regional Development Organizations (**RDO**s), or similar consortia to support regionalization of utilities. • Leverage existing funding opportunities to support long term operations, maintenance, and staffing of programs and projects. • Leverage federal and state level research as launching pad for mitigation investment decisions. • Build capacity for local entities, municipalities and regional partnerships to gain access to mitigation assistance through multiple grant programs. • EPA requires Municipal stormwater systems (MS4s) in urbanized areas, as well as small MS4s outside the urbanized areas, to obtain NPDES permit coverage for their stormwater discharges. • PRASA's new fiscal plan requires a $303 million investment to reduce commercial and physical non-revenue water losses. To help achieve long-term financial sustainability, improve water quality, and increase resiliency. • Puerto Rico Permit Management Office has a certification for Green Permits and professional requirements to support this sector.

Contributors and Mitigators of Instability for:

Water and Wastewater Lifeline Sector

	Contributors	Mitigators
Structure and Infrastructure	• Forty percent (40%) of the population is not connected to PRASA's wastewater treatment service and mainly manage their wastewater through septic tanks or cesspools. Some discharge directly to PR waters. • A 2019 report estimated that PRASA lost fifty-nine percent (59%) of water from its system: forty-nine percent (49%) to pipe ruptures and leakage, and eight percent (8%) to unauthorized water consumption, inaccurate estimates, and water tank overflows. • Seven (7) of Puerto Rico's dams are not used for their original purpose. These dams currently are sediment-filled and lack maintenance. • Estimates indicate reservoir capacity has been reduced by more than fifty percent (50%) at the Dos Bocas, Loco, Loíza and Lucchetti dams which require maintenance and dredging to restore capacity • Septic tank locations and conditions are unknown, and depend on private homeowner maintenance.	• The PRASA infrastructure has been built to serve a population of 3.8 million habitants. Because population and sprawl have reduced considerably in the past decade, the Water Authority can focus on the improvement of current systems versus expansion. • PRASA's proposed smart meter system could decrease loss of water due to leakage and theft.
Natural Environment	• Loss of vegetative coverage near water reservoirs leads to increase in sedimentation and loss of storage capacity.	• Constant and high grade of rain and runoff could replenish the reservoir and residential water collection systems. • Watershed restoration has proven to protect life and property. Continue to restore and protect mangroves and wetlands.
Education and Awareness	• Community water systems (non-PRASA) vary from highly organized, registered systems to unregistered, unorganized systems that may require significant maintenance. There is a high need for continuous capacity building on non-PRASA water systems which are vulnerable and suffer from lack of resources. Representatives from community water systems have shown lack of trust in official institutions for recovery. • There is a need for design and technical maintenance expertise of new green infrastructure water management technologies. • Although Federal funding exists for implementation of green infrastructure practices, lack of capacity to develop proposals limits application and prospect applicants. • Reimbursement funding programs are seen as unviable to communities with limited funding.	• Increased stakeholder engagement to communicate common understanding of risk and gather local insight for solutions. • Minimize displacement of homeowners and vulnerable communities through regional, strategic, and multi-sector mitigation. • Community-driven regional efforts have emerged after the 2017 storms, like the organization OSAN that promotes peer-to-peer capacity building approach. These may be a best practice model. • On-site rain catchment systems for residential properties have proven to be effective and easy to implement. • Specialized academic institutions present an area of opportunity, continued education and innovation. • Regional Development organizations with USDA and RCAP, can leverage funding and make connection to create opportunities.

Stormwater and Flood Mitigation

Puerto Rico receives significant rainfall in most of the island regions. Between 2000 and 2018, Puerto Rico received an annual average of seventy (70) inches, more than twice the average rainfall for the continental US Portions of the Island can receive as much as 200 inches of rain per year. The high rainfall amounts result in large volumes of storm runoff that pose significant flood risks for urban and rural areas. Thus, stormwater and flood mitigation are important aspects of comprehensive water management.

Puerto Rico's stormwater systems are highly decentralized. Stormwater management functions are predominantly the responsibility of municipalities, which apply for permits administered by the EPA to discharge stormwater effluent to waterways. However, PRASA manages stormwater in some urban areas and maintains a series of combined sewer systems that convey both wastewater and stormwater. Stormwater is also managed by DTPW and the PRHTA According to EPA, there were eighty-five (85) permitted municipal separate storm sewer systems (commonly abbreviated as **MS4**) in Puerto Rico in 2018. These systems are managed by different municipalities, institutions, and/or agencies. This fragmentation of management authority poses challenges to coordination and comprehensive water resources management.

Flood mitigation infrastructure in Puerto Rico includes dikes, levees, and seawalls designed to protect coastal areas and assets from tidal flooding and storm surge, as well as levee systems that have been constructed inland to protect against riverine and urban flooding. Puerto Rico's DNER manages fourteen (14) levees spanning thirty-two (32) miles, which are also registered in the National Levee Database of the USACE.[183] In addition, there are at least thirteen (13) additional levee systems, likely owned and operated by municipalities, across Puerto Rico.[184]

Water Resource Management System

Water management in Puerto Rico extends beyond drinking water and wastewater to include stormwater, flood control, and integrated water management, which are overseen by a number of federal and government of Puerto Rico agencies, private businesses, and community organizations that have responsibilities that often overlap. Moreover, different parties in the water sector have differential influence over decision-making processes and policy prioritization. As a result, while much of the responsibility for the management of drinking water in Puerto Rico is centralized within PRASA, overall, water sector governance is a complex process which can be a challenge to comprehensive water resource management planning, decision-making, and investment. While all water sector activities and planning affect the water sector management, DNER has the overarching responsibility for water management, including watershed and groundwater management, and affiliated activities such as land-use planning, erosion and sediment planning, and climate planning. The table below illustrates Puerto Rico agencies responsible for water resource management and oversight.

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[183] USACE website https://levees.sec.usace.army.mil/#/
[184] Governor of Puerto Rico, Build Back Better Puerto Rico: Request for Federal Assistance for Disaster Recovery, 2017.

Government of Puerto Rico Agency Roles in Water Resource Management	
Agency	**Role**
Puerto Rico Aqueduct and Sewer Authority (PRASA)	Water and wastewater service, and stormwater conveyance
Municipalities	Stormwater management, water and wastewater service
Department of Natural and Environmental Resources (DNER)	Watershed management and environmental protection, and water storage
Puerto Rico Electric Power Authority (PREPA)	Irrigation conveyance systems and, water storage (dams)
Department of Health (PRDOH)	Drinking water monitoring
Environmental Quality Board (DNER)	Water and environmental quality
Puerto Rico Infrastructure Financing Authority (PRIFA)	Financial oversight
Public Service Regulatory Board (PRPSRB)	Utility regulation

Prioritizing CDBG-MIT funding to develop a more resilient water and wastewater sector

A key strategy for improving resilience will be to build and enhance the capacity of water sector management agencies to develop and implement a comprehensive, regional approach to water resource management to identify opportunities and projects that simultaneously address multiple risks such as flood mitigation, insufficient water supply capacity, and drought, while potentially creating opportunities for economic development and socially beneficial recreational activities.

Much of the risk to the water and wastewater lifeline due to natural hazards is associated with a disruption of the power grid. Puerto Rico should prioritize projects that decrease water and wastewater and storm management facilities' reliance on the power grid in a resilient manner. While backup generators powered with fossil fuels are available at many of these facilities, their vulnerability to damage and disruption of the transportation supply chain limits their resilience. Renewable back-up energy supply alternatives and the hardening of backup energy equipment should be prioritized to create a resilient water sector that protects lives from flooding and lack of water during and after a disaster.

Other key opportunities for enhancing resilience in Puerto Rico's water sector include upgrading physical infrastructure as well as asset management and operational systems, with the objective of developing systems that are better hardened against extreme events but also more flexible and efficient. In addition, building capacity among water sector management organizations and personnel can enhance efficiency, contingency planning, and the ability to take advantage of new technologies and practices. Meanwhile, improving situational awareness of water sector assets and developing performance metrics that can be tracked in real time can provide early warning of problems and accelerate emergency responses. An overarching goal of enhancing capacity within the water sector is enhancing interoperability and flexibility. For example, reconciling operations and management of shared water infrastructure systems (e.g., DNER pump stations and municipal stormwater systems) through joint or centralized management could hasten recovery efforts and improve general day-to-day management.

ANALYSIS OF SECONDARY LIFELINES

The Health and Medical, Hazardous Materials Management, and Safety and Security lifelines are critically important to emergency and rapid lifesaving response in a hazardous event. These lifelines are characterized as secondary for the purpose of the risk assessment only because the investment strategy in this program focuses on the critical stabilization of those lifelines upon which others depend. However, when those central lifelines (such as energy) fail, and when health and safety risks become compounded by contaminated water, vector-borne illness, lack of refrigeration, and scarcity of resources such as food, prescriptions, and medical supplies, these lifelines must emerge with surge strength to address immediate human needs.

SECONDARY LIFELINE SECTORS IN FOOD, WATER, and SHELTER

The Housing sector and Agriculture sector of the Food, Water, and Shelter Lifeline are two key sectors tied to the basic needs of every Puerto Rican. Flood and landslide threatened homes leave households vulnerable to the next disaster event, and lack of locally-supplied agriculture products leave Puerto Rican households dependent on complex supply chains for basic sustenance.

Contributors and Mitigators of Instability for:
Housing and Agriculture Sector

Local Planning and Regulation

Contributors	Mitigators
Housing • Less than four percent (4%) of households in Puerto Rico had flood insurance going into Hurricane María.[185] • Approximately twenty-two percent (22%) of the population is located in the FEMA Advisory 100-year Floodplain. • Lack of access to adequate and up-to-date parcel and land ownership registry hinders the ability of households to enroll in insurance or access federal assistance programs. • Vulnerable populations, citizens that are homeless, and citizens at-risk of homelessness are unable to recover quickly from disaster events and lack housing options.	Housing • Support modernization of land use, code compliance, and governance structures that support mitigation to increase household ability to qualify for insurance. • Implement of GeoFrame Program and Housing Title Clearance Program under CDBG-DR to increase household ability to qualify for insurance. • Leverage federal and state level research as launching pad for mitigation investment decisions. • Utilize multi-family assistance program under CDBG-DR to assist vulnerable populations, homeless citizens, and citizens at-risk of homelessness.
Agriculture • Most of the Island's food is imported, and most of it is passed through the Port of San Juan. • Al large food warehouses are located next to the San Juan Port. • Food is highly dependent on functioning supply chains.	Agriculture • Support data-driven decision making by providing updated and transparent data collection. • Set up RDOs, or similar consortia to support agricultural development. • Build capacity for local agriculture business and regional partnerships to gain access to mitigation assistance through multiple grant programs.

[185] Wharton Risk Center Issue Brief March 2018, *Residential Flood Insurance in Puerto Rico.* Accessed at: https://riskcenter.wharton.upenn.edu/wp-content/uploads/2018/03/WRCib2018_Flood-Insurance-in-Puerto-Rico.pdf

Contributors and Mitigators of Instability for:
Housing and Agriculture Sector

	Contributors	Mitigators
Structure and Infrastructure	Housing • Houses in Puerto Rico are made of slab-on-grade concrete, and have concrete roofs. This generally makes them more susceptible to earthquake damage due to lack of pliability. It also makes them difficult to elevate in a cost-effective manner. • This construction also makes elevation a difficult and costly activity as concrete homes lose their structural integrity when they are lifted. Agriculture • Most small farm operations lack the equipment necessary to get their crop from farm to market such as refrigeration, trucks, and farm equipment. • The increase in solar farms can threaten use of agricultural lands for agriculture.	Housing • Houses in Puerto Rico are made of slab-on-grade concrete, and have concrete roofs. This generally makes them more resistant to flood damage. Agriculture • RE-Grow PR Urban-Rural Agriculture Program under the PRDOH CDBG-DR grant, is serving to revitalize the agriculture industry in a movement toward food security for the Island.
Natural Environment	Housing • Puerto Rico soil is prone to liquefaction and landslides that threaten homes during flood and earthquake events. • Sea Level Rise and rain-induced flooding impact thousands of homes each year. Agriculture • Puerto Rico is prone to weather-related disaster events which can cause wide-scale crop damage and loss.	Agriculture • The Puerto Rico climate is ideal for extended agricultural seasons.
Education and Awareness	Housing • There is a need for increased education on risk and risk awareness • Housing communities that sustain repetitive loss need advocacy representation to increase public awareness of these vulnerable areas. Agriculture • Modern and affordable solutions and public outreach to implement those solutions is needed to increase small farmer access to market.	Housing • Increase stakeholder engagement to communicate common understanding of risk and gather local insight for solutions. • Minimize displacement of homeowners and vulnerable communities through regional, strategic, and multi-sector mitigation. Agriculture • Increase stakeholder engagement to communicate common understanding of risk and gather local insight for solutions. • Build partnerships between Regional Development organizations and USDA, to leverage funding and create opportunities.

Housing Sector

While Housing meets essential human needs to provide refuge from the elements, the housing stock does not represent a lifeline upon which others depend. It is therefore considered a secondary lifeline in this analysis.

Accurate parcel and housing stock data is a critical need for Puerto Rico and is currently being addressed through the Geospatial Framework Program. However, in the interim, PRDOH has completed an analysis of flood data as the top risk to housing stock, and the location of residents as represented in census data.

PRDOH used population data collected from the American Community Survey products developed for HUD's LMI block group dataset the block group level..[186] This population data was geo-processed with the ESRI ArcGIS Pro Create Random Points tool to randomly distribute the population (Low- Moderate Universe). The data was then analyzed based on location within the High, Medium High, and Medium risk areas developed as part of the Risk Assessment. The map below shows the location of the High, Medium High, and Medium risk areas in Puerto Rico.

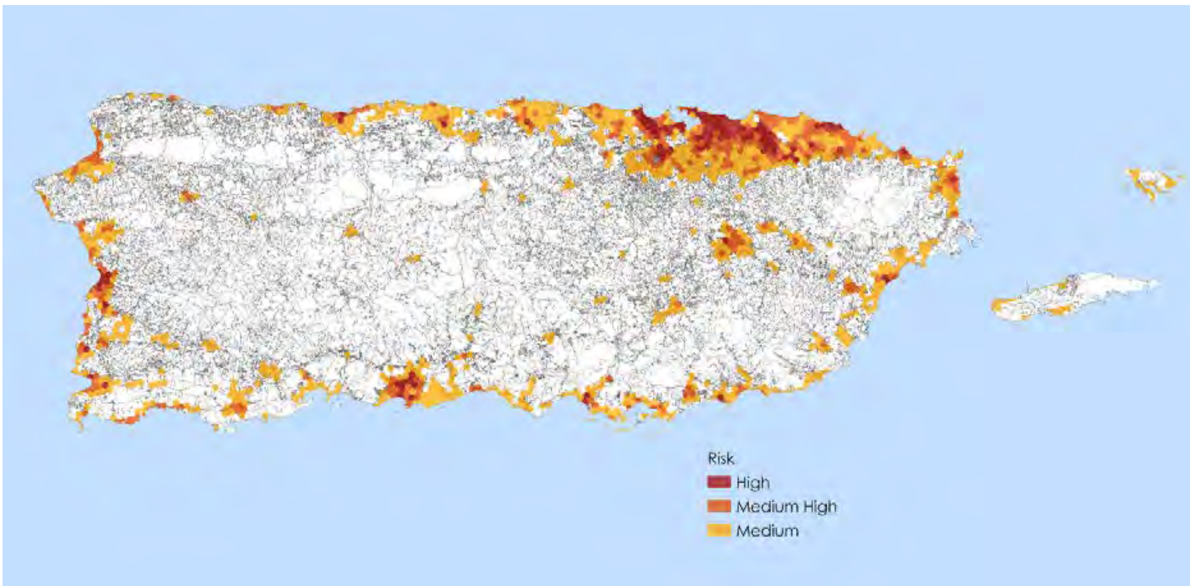

Figure 74. Population in High, Medium High, and Medium Risk Areas in Puerto Rico

Of the population in Puerto Rico, approximately eleven percent (11%) live in High-risk areas, approximately thirteen percent (13%) live in Medium High-risk areas and approximately twenty-three percent (23%) of the people live in Medium risk areas. Based on the average number of persons per-home in Puerto Rico, this represents in total roughly 619,000 homes. The table on the following page shows the estimated population, percentage, and estimated number of homes in the High, Medium High, and Medium Risk areas.

Estimated Population, Percentage, and Estimated Number of Homes in High, Medium High, and Medium Risk Areas			
Risk	**Estimated Population**	**Percent of ACS Population**	**Estimated Number of Homes***
High	393,024	11%	146,651
Medium High	464,329	13%	173,257

[186] LMISD - All Block Groups, Based on 2011-2015 ACS. https://www.hudexchange.info/programs/acs-low-mod-summary-data/acs-low-mod-summary-data-block-groups-places/

Estimated Population, Percentage, and Estimated Number of Homes in High, Medium High, and Medium Risk Areas			
Risk	**Estimated Population**	**Percent of ACS Population**	**Estimated Number of Homes***
Medium	801,568	23%	299,093
Total			**619,000**
*Estimated number of homes is based on 2018: ACS 1-Year Estimates; 2.68 persons per-home in Puerto Rico. 1,179,637 estimated homes in Puerto Rico;			

In addition to risk, populations were also analyzed based on their location within FEMA Special Flood Hazard Areas. After Hurricane María, FEMA developed an Advisory 100-year Special Flood Hazard (**SFHA**) area based on inundation resulting from the hurricane[3].scurrent FEMA 100-year Floodplain (left) and the FEMA Advisory 100-year Floodplain (right).

FEMA 100-year Floodplain **FEMA Advisory 100-year Floodplain**

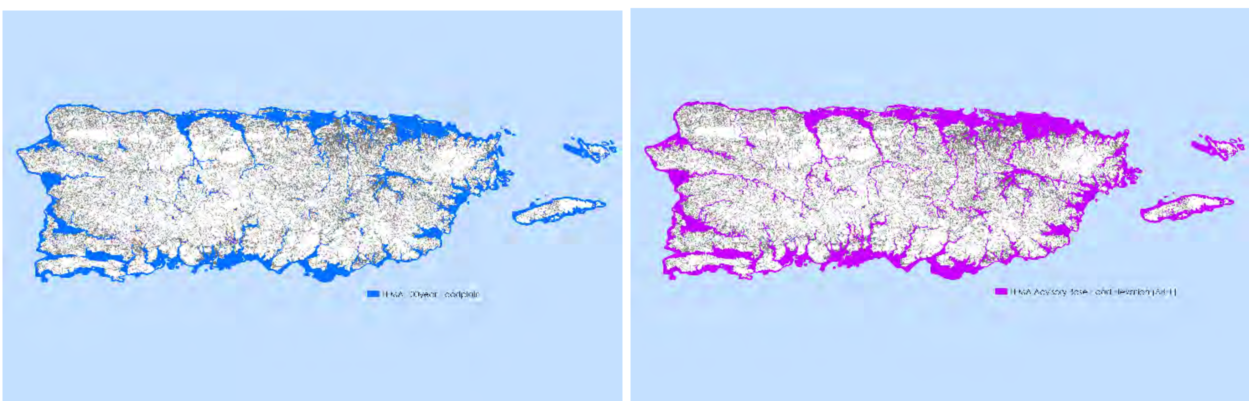

Figure 75. FEMA 100-year Floodplain and FEMA Advisory 100-year Floodplain

Of the population in Puerto Rico, approximately sixteen percent (16%) reside within the FEMA 100-year Floodplain. That number increases to twenty-two percent (22%) when compared to the FEMA Advisory 100-year Floodplain. Based on the average number of persons per-home in Puerto Rico, this represents in total roughly 216,055 homes. The table on the page that follows shows the estimated population, percentage, and estimated number of homes in the FEMA 100-year Floodplain and the FEMA Advisory 100-year Floodplain.

Estimated Population, Percentage and Estimated Number of Homes in the FEMA 100-year Floodplain and the FEMA Advisory 100-year Floodplain			
Evaluated SFHA	Estimated Population	Percent of ACS Population	Estimated Number of Homes
FEMA 100-year Floodplain	579,028	16%	216,055
FEMA Advisory 100-year Floodplain	795,822	22%	296,949
*Estimated number of homes is based on 2018: ACS 1-Year Estimates; 2.68 persons per-home in Puerto Rico. 1,179,637 estimated homes in Puerto Rico;			

Addressing High-Risk Housing Needs

In fact, through research of flood and landslide risks associated with rain, tropical storm, and hurricane events, and flooding caused by coastal erosion and sea level rise, PRDOH has observed a clear need for relocation of residents in high-risk flood and landslide-threatened homes, to remove them from repetitive loss and harm through a buyout or relocation option that provides a swift and effective remedy against continued threat.

Food and Agriculture Sector

Puerto Rico's agriculture industry is in recovery after the hurricane events. The hurricanes impacted staple crops such as coffee, plantains, banana, yams, pigeon peas, coconut and eggplant, which carries economic impacts for successive years due to growth and maturation cycles. Loss of agricultural production in the post-disaster period has highlighted significant food security challenges and supply chain deficiencies in both urban and rural areas, beginning with the ability to maintain businesses and the supporting supply chains that industry sector depends on.

As Puerto Rico focuses on its recovery, programs like RE-Grow PR Urban-Rural Agriculture Program under the PRDOH CDBG-DR grant, are serving to revitalize the agriculture industry in a movement toward food security for the Island.

Food security exists when all people, at any moment, have physical and economic access to sufficient, safe and nourishing foodstuffs that meet the food requirements of the human body, so as to lead a healthy and active life.

Food security involves four aspects commonly referred to as the Four Dimensions of Food Security: [187]

1. Availability – food availability can be affected by the type of production and whether it is locally available.
2. Access – individuals and households must be able to afford and acquire sufficient food to support a healthy, nutritious diet, or have access to sufficient resources needed to grow one's own food.
3. Utilization – individuals and households must be able to access sufficient quantity and diversity of foods to meet nutritional needs in terms of calories, vitamins, proteins, and micronutrients, and food must be unspoiled and safe for consumption.
4. Stabilization – sufficient, nutritious food sources must be available in a stable manner to avoid instances of malnutrition and in order for people not to feel food-insecure.

The 2017 Puerto Rico Census of Agriculture schedule data collection process began late due to disruptions from Hurricanes Irma and María. Due to the lack of the communication infrastructure necessary to continue with census activities the USDA, National Agricultural Statistics Service (**NASS**) decided to delay the 2017 Puerto Rico Census of Agriculture. The census was delayed for a whole year to give farmers and government agencies time to recover from such massive devastation. The report forms were scheduled to be mailed-out on December 2018. This mail-out was delayed yet again by the Federal government shutdown at the end of 2018. The report forms were finally mailed to respondents on February 5, 2019.[188]

Health and Medical Lifeline

The capacity to deliver the necessary healthcare services, the stability of the system and communications within the health and medical lifeline components (medical care, patient movement, fatality management, public health and medical supply chain) is critical in the multi-hazard landscape that Puerto Rico faces. As a further matter, the demographic profile includes an aging population, high rates of poverty and some chronic health conditions.

The healthcare system is a mix of institutions including governmental, private non-profit and private for-profit entities. Agreements between these institutions established before a disaster event become critical and must be filed and endorsed by the Department of Health.

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[187] What is Food Security, FCRN foodsource. March 12, 2018. Accessed at: https://www.foodsource.org.uk/building-blocks/what-food-security#:~:text=2.3%20Definition,-Together%2C%20the%20importance&text=and%20Agriculture%20Organisation%3A-,%E2%80%9CFood%20security%20exists%20when%20all%20people%2C%20at%20all%20times%2C,an%20active%20and%20healthy%20life.%E2%80%9D

[188] 2017 Census of Agriculture, Puerto Rico (2018). United State Department of Agriculture. June 2020. Accessed at: https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Outlying_Areas/Puerto_Rico/prv1.pdf

The contributors and mitigators of instability consider infrastructure, labor force, and public access concerns.

Contributors and Mitigators of Instability in Health and Medical Lifeline

	Contributors	Mitigators
Local Planning and Regulation	• Stakeholders expressed an urgent need for data sharing, improved communications between healthcare and environmental remediation and control entities for quick response and transparency, without compromising protected health information (**PHI**). • There are a high number of asthma and diabetes patients in Puerto Rico that are super-utilizers.[189] that make a large impact on the medical system. In the event of a disaster, these patients are at extremely high risk. • Municipalities reported after Hurricanes Irma and María that access to some health services, including dialysis centers and highly specialized medical care, was available in less than half of the jurisdictions. • Centro Médico is a full-service scattered-campus hospital system that serves the entire Caribbean region but lacks sufficient infrastructure and equipment for trauma center, and is highly susceptible to power and water loss. After the hurricanes, the hospital had to close down operating rooms and other parts of the facility due to lack of power. • In general, Puerto Ricans are medically underserved. The medical industry has weak institutional capacity and inadequate human and financial resources.	• Develop network of Regional Hub-and-Spoke facilities coordinated by the US Department of Health and Human Services (**HHS**) consisting of 17 hubs and 35 spokes. The Hub-and-Spoke model coordinates the emergency operation through an incident command, between a primary facility (Hub) and a satellite (Spoke) in the event of an emergency or disaster. This model directs resources and the continuous exchange of information between facilities in the health benefits system. • Implement mutual aid agreements for quick response and communication during emergencies. Agreements between these institutions established before a disaster event becomes critical and must be filed and endorsed by the Puerto Rico Department of Health (**PRDOH**). • Support data-driven decision making by providing updated and transparent data collection. Consider applications like the CDC's Comprehensive Disaster Assessment and Readiness Tool (**CDART**). • Leverage existing funding opportunities to support long term operations, maintenance, and staffing of programs and projects. • Leverage EDA funds for the creation of EDDs that can support community-based solutions. • As of September 2018, all hospitals and dialysis facilities have current emergency operations plans.
Structure and Infrastructure	• Healthcare facilities require retrofits for infrastructure that also includes water and energy backup systems. • Retrofit dialysis facilities need to include water tanks that provide service redundancy that is necessary for patient care. • Vieques and Culebra are islands without proper healthcare facilities to support their population. • Need for hardened electrical grid supported by alternative energy generators to keep healthcare facilities and services available in a future disaster. •	• Telemedicine has potential to enhance access to scarce specialty medical services. • Cogeneration and trigeneration technology could prevent loss of service in the event of another power failure. This technology can also lower operational costs that can be transferred to costs for increased patient care services.

[189] Super-utilizers are patients who use the healthcare system with extraordinary frequency

Contributors and Mitigators of Instability in Health and Medical Lifeline

	Contributors	Mitigators
Natural Environment	• Frequent weather-related disaster events cause emotional distress and tax the mental health of Puerto Rican residents. • Underutilization of farm lands to grow abundant crops that meet the local need for nutritious food sources contributes to diet-based health problems.	• Public health threats can be minimized through water resource management, vector control, solid waste management, food security and food safety.
Education and Awareness	• There is a need to supplement limited access to healthcare with trained community healthcare providers. • There is a need for better patient transportation coordination and trained staff. • There is a large migration of the Medical workforce (doctors, nurses, first responders, paramedics, etc.). According to the Puerto Rico College of Physicians and Surgeons, an estimated 14,000 medical specialists in the last five years have emigrated There is limited access to preventive programs, including psychosocial support, particularly for low-income Puerto Ricans.	• Increase stakeholder engagement to communicate common understanding of risk and gather local insight for solutions. • Build capacity for local entities, municipalities, and regional partnerships to gain access to mitigation assistance through multiple grant programs. • Leverage community-based knowledge and input compiled by Federal recovery support functions during stakeholder engagements such as HHS-RSF to grasp needs and proposed solutions in healthcare and social services.

Harden Medical Infrastructure and Invest in Independent Energy and Communications Systems

Every hospital and medical clinic in Puerto Rico lost power when the hurricanes hit. Several of the backup generator systems failed due to damage or lacked sufficient fuel to keep buildings operating and able to run life-saving equipment such as nebulizers and dialysis machines, or to keep critical medicine refrigerated.

Twenty-three (23) hospital facilities filed hurricane-damage claims with FEMA's Public Assistance (**PA**) program. Shown in the map below.

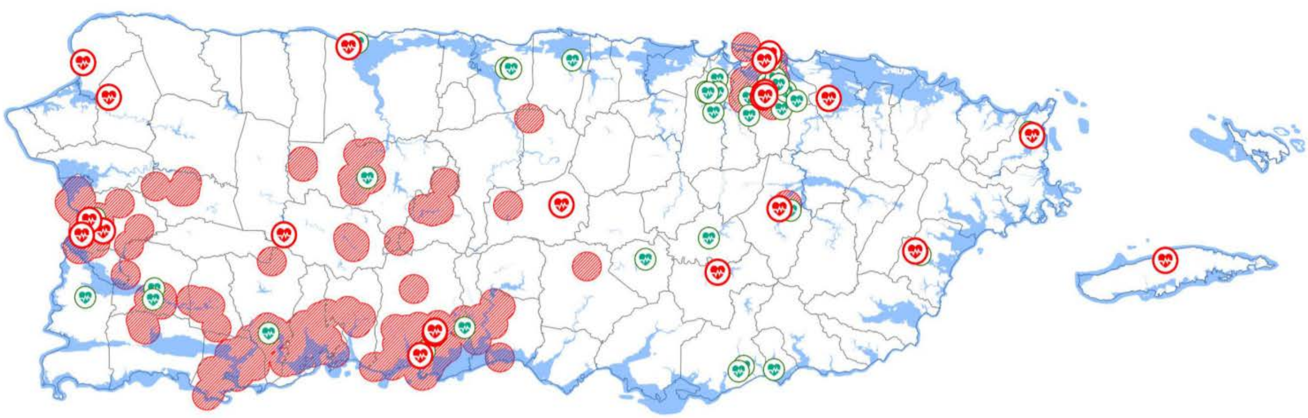

Figure 76. Map of hospital facilities that experienced damage from hurricanes

Healthcare Facilities and Risk*				
Healthcare Facilities in Puerto Rico**	Healthcare Facilities Receiving FEMA PA Assistance	Hospitals in Puerto Rico***	Healthcare Facilities in FEMA Floodplain	Healthcare Facilitates in Area Affected by Earthquake
73	23	66	6	41

* FEMA data accessed on 4/7/2020
** Healthcare facilities includes children's hospitals, general acute care facilities, psychiatric facilities, rehabilitation facilities, and facilities classified as special
*** Excludes psychiatric, rehabilitation, and special facilities

The US Department of Health and Human Services (**HHS**) informed PRDOH through stakeholder engagement that sixty-eight (68) hospitals and more than 100 health clinics experienced structural damage from the hurricanes, and many backup generators were damaged or destroyed, presenting operational challenges during the prolonged Island-wide power outage.[190] Because of the power failure and the dependence on fuel, health and medical services were placed at risk, over the course of the disaster response phase several hundred lives were lost.

Most of Puerto Rico's hospital buildings survived Hurricane María, though not all. The hospital in Vieques was destroyed. Other hospitals lost power, communications, water, and while the buildings stood, they were unable to function. The equipment did not work; condensation from lack of air conditioning damaged electrical equipment; and hospital staff could not be reached and could not make it to the hospital because of infrastructure damage.

[190] Information obtained from US Department of Health and Human Services, Health and Social Services Recovery during stakeholder meeting held June 22, 2020.

Leverage Social and Community Assets When Infrastructure Fails

Through Stakeholder meetings, PRDOH learned that among the lessons learned from active healthcare professionals for the period before, during, and immediately following a disaster:

- Maintain open lines of communication between all departments and conduct status meetings at least twice (2) a day.
- Include residents; they are always on the front lines and can provide valuable contributions.
- Think about all possible means for communication: from verbal, messenger, and other nontechnological means to satellite telephones, social media and WhatsApp.
- Provide for redundant communication approaches with hospital leadership, including the medical director, department chairs, director of graduate medical education, chief executive officer, and chief operating officers.
- Anticipate challenges and try to solve outstanding issues before an event.
- Keep an inventory of supplies, medications, and equipment that are used frequently, and ensure you have enough supplies on hand for at least two (2) weeks.
- Have a two (2)-week supply of food and water for faculty and residents in the hospital.
- Cancel patient appointments and all surgeries scheduled twenty-four (24) hours prior to the event. Discharge as many patients as possible from the hospital, and ensure they go to safe places.
- Conduct disaster drills regularly.
- Ask for help. Collaboration helped save lives.
- Ensure that individuals and institutions have enough cash to purchase goods and gasoline after the emergency.
- Demonstrate empathy to residents, faculty, administrators, employees, and patients; they are all living the same tragedy.
- Monitor stress and burnout in residents and instruct them about self-care to improve well-being during difficult times.
- The ''old way'' may be the best way after a disaster.[191]

Resiliency of the buildings themselves is one aspect but ensuring resiliency of power and communication systems is also key. Installing micrgrids at hospitals to ensure they have power for air conditioning, equipment, communications and to refrigerate medication is one (1) strategy under consideration to enhance resiliency going forward, but making sure facilities have access to communication is also essential. Following the hurricane, San Juan's Hospital del Niño received 800 solar panels from Tesla.

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[191] Rodriguez de Arzola, Olga, MD., Journal of Graduate Medical Education, Page 478m August 2018. https://www.jgme.org/doi/pdf/10.4300/JGME-D-18-00547.1

Modernize Equipment that Supports Long-Term Resilience

The Health and Medical lifeline in Puerto Rico lack modern technology to operate efficiently given the high cost of energy. Several hospitals that wholly serve communities do so without reliable access to water and wastewater infrastructure. For the Health and Medical lifeline, aging and inadequate medical facilities and personnel, lack of adequate personnel, lack of specialty and general medical professionals on the Island, lack of modern medical equipment, and a dependence on social compacts to piece together medical services between facilities pose the highest risks.

The healthcare system in Puerto Rico has also been crippled by recent disaster events including the hurricanes, earthquakes and COVID-19. The COVID-19 pandemic has placed a new demand on medical systems worldwide, but the systemic underfunding in the medical system in Puerto Rico has perpetuated further challenges.

COVID-19 relief funds had awarded some $2.2 billion in federal assistance by July 2020, of which, as of April 2020, $1,431,237 had been distributed to twenty-two (22) health centers.[192]

Strategically Increase Access through Telemedicine, Support Services

A PRDOH analysis of hospital facility locations and analysis of drive time revealed that twenty-two percent (22%) of the population is more than thirty (30) minutes away from the nearest hospital facility. This high-level analysis is merely a glimpse into healthcare access, it does not take into account the nature of services needed for the patient or alignment with specialty at the nearest location.

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[192] Puerto Rico Coronavirus (COVID-19) Awards , Health Resources and Services Administration, accessed on July 15, 2020 at: https://bphc.hrsa.gov/emergency-response/coronavirus-covid19-FY2020-awards/pr

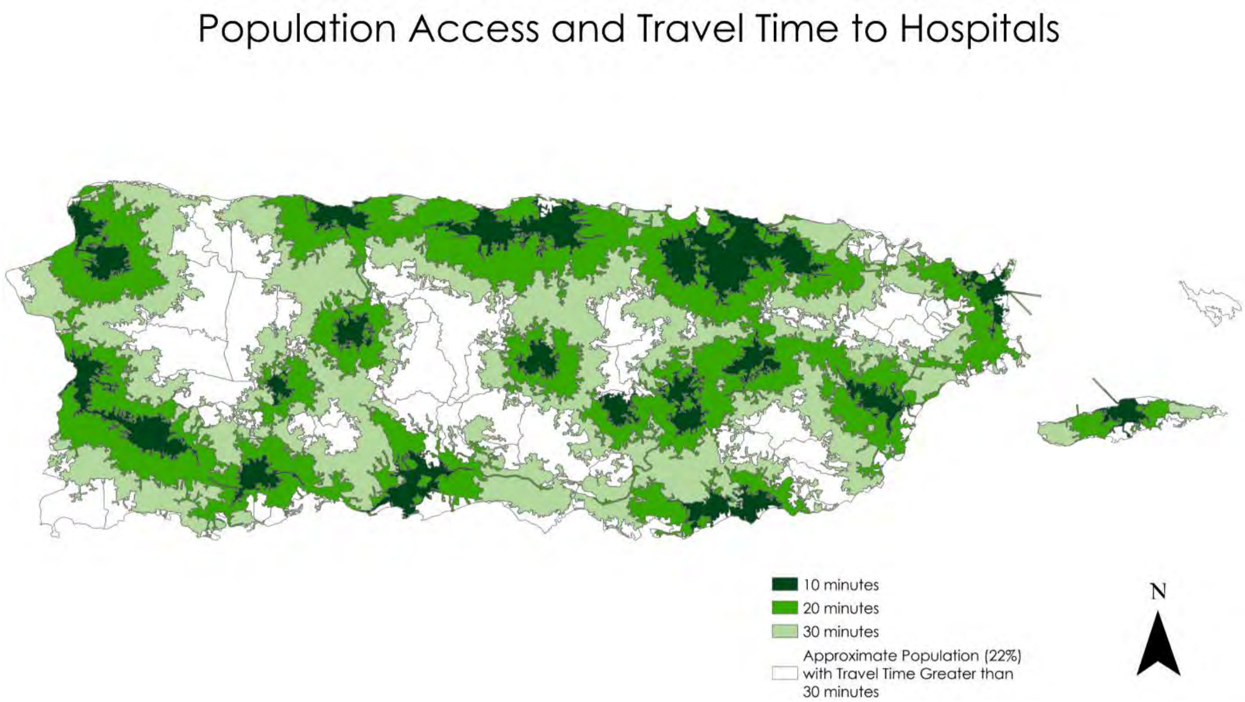

Figure 77. Analysis of population access and travel time to hospital facilities

This lack of access can be resolved in two (2) ways: by investing in new facilities in underserved areas, or expanding the reach of telemedicine services coupled with preventative care solutions such as wraparound services and community health workers.

Prevent Healthcare Shortfalls by Recruiting and Retaining Medical Specialists and Support Staff

Of the practicing physicians in Puerto Rico:

- Forty percent (40%) of Puerto Rico's 9,874 active physicians are primary physicians
- Fifty percent (50%) come from unaccredited international schools
- Nearly sixty-seven percent (67%) of practicing primary care physicians are older than fifty-five (55) years, compared with forty-three (43%) nationwide.[193]

The US Health Resources and Services Administration (**HRSA**) has deemed seventy-two (72) of Puerto Rico's seventy-eight (78) municipalities medically underserved.

HRSA has identified thirty-two (32) primary care health professional shortage areas (**HPSA**s) with a population-to–primary care provider ratio of 3,500:1 or higher.

According to HRSA guidelines:

- Twenty three percent (23%) of municipalities have a shortage of pediatricians,
- Sixty eight percent (68%) had a shortage of Obstetrician/Gynecologists

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[193] Wilkinson, Elizabeth, BA; David Killeen, MD; Gabriel José Pérez-López, MD; and Yalda Jabbarpour, MD. "A Shrinking Primary Care Workforce in Puerto Rico". Robert Graham Center Report. Page 1. December 13. 2019.

- Sixty four percent (64%) had a shortage of psychiatrists

Anecdotal evidence also pointed to a shortage of surgeons, pulmonologists, neurologists, oncologists, endocrinologists, and emergency physicians. Only three (3) neurosurgeons were thought to be practicing on the Island.

Two Doctors Leave the Island Every Day

After Hurricanes Irma and María, the migration of physicians has doubled to two (2) doctors per day.[194]

Health Policy Center research respondents said physicians migrate because of:

- Lack of training opportunities
- Low salaries for medical residents relative to the US coupled with a high cost of living
- Difficulty becoming certified to contract with PR; the number of resident seats available in Puerto Rico is significantly less than the number of medical graduates, forcing graduates to complete their studies elsewhere. [195]

Meanwhile, provider groups on the US mainland actively recruit Puerto Rican physicians because of demand for bicultural and bilingual physicians to treat Hispanic patients.

Puerto Rico may have eased this situation recently by allowing both Nurse Practitioners and Physician Assistants to be licensed in the territory, which they previously were not.[196]

Support Policy Reform that Leads to a Resilient Healthcare System

Puerto Rico used to have a national healthcare system. As described in a 2017 report by the Urban Institute's Health Policy Center, this public health care system, codified in an early version of PR's constitution, emphasized prevention and sanitation; health care was considered a fundamental human right. Many stakeholders interviewed by Health Policy Center researchers indicated that the transition from this public health system to a managed care system in the 1990s, caused a cascade of changes that, in tandem with a struggling economy, weakened the country's ability to care for its people. [197]

These changes include:

- Shifting to a Medicare system that is underfunded in US territories like Puerto Rico

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[194] Rodríguez de Arzola, Olga. Medical Specialty Development Plan in Puerto Rico. Southwest Regional Academic Center. Page 5, Oct 2018.

[195] Rodríguez de Arzola, Olga. Medical Specialty Development Plan in Puerto Rico. Southwest Regional Academic Center. Page 5, Oct 2018.

[196] Rodríguez de Arzola, Olga. Medical Specialty Development Plan in Puerto Rico. Southwest Regional Academic Center. Page 5, Oct 2018.

[197] Perreira, Krista, et al. *Puerto Rico Health Care Infrastructure Assessment*. Urban Institute, Jan. 2017, www.urban.org/sites/default/files/publication/87011/2001050-puerto-rico-health-care-infratructure-assessment-site-visit-report_1.pdf

- Providers changing their approach from public health toward maximizing profits in fee-for-service practices
- A reduction in coordinated care and referrals for essential services to specialists
- A general undermining of medical education and training because of lack of residency opportunities that contribute to the emigration of many recently graduated doctors to the mainland.[198]

The introduction of the profit motive in the medical system has reshaped much of the way the medical community functions and contributed to an exodus of medical professionals to the mainland. Previously providers had been, ostensibly, government employees and coordination of care was common. But, when the territory shifted to managed care, providers' incomes shifted to fee-for-service. That altered many aspects of how medicine is practiced in Puerto Rico.

Providers began to book excessive numbers of patients per day—up to ninety (90) in some cases. At the same time, they sharply curtailed the number of referrals they made to specialists such as pediatricians, endocrinologists, neurologists, pulmonologists, and cardiologists. Rather than emphasize coordinated care for best outcomes, the focus of providers and managed care systems became control utilization to minimize costs.

Patients pay for their healthcare monthly to an independent physician association which must cover all costs on this small monthly amount. One reason physicians fail to make referrals is that patients have the opportunity to change their plans monthly and many do so to cover a specific procedure or take advantage of discounts. Consequently, primary care physicians are incentivized to restrict referrals for preventive services such as mammograms or specialty services.

The dearth of referrals has led many specialists to move to the contiguous U.S. Medicaid managed care plans reported difficulties contracting with sufficient numbers of specialists.

Healthcare Funding Weakened

The transition from a public healthcare system to a managed care system coincided with other changes that sent Puerto Rico's economy into decline. Between 2001 and 2006, the U.S. phased out Section 936 of the Internal Revenue Code, which granted tax incentives to US corporations operating in Puerto Rico. This change dramatically reduced the tax base that would have been drawn upon to pay for healthcare. [82]

In addition, Puerto Rico typically issued municipal bonds to pay toward healthcare costs. But when it defaulted on its debt, those funds were no longer available. And after

[198] Perreira, Krista, et al. ***Puerto Rico Health Care Infrastructure Assessment***. Urban Institute, Jan. 2017, www.urban.org/sites/default/files/publication/87011/2001050-puerto-rico-health-care-infratructure-assessment-site-visit-report_1.pdf

Hurricane María, hedge funds acquired billions in Puerto Rican debt, leaving the Island more impoverished.

Disproportionate Medicaid Allotments

A large percentage of the population relies on Medicare as its primary insurance:

- Puerto Rico's Medicaid/CHIP program thirty-nine percent (39%)
- Puerto Rico's Medicare Advantage sixteen percent (16%)
- Traditional Medicare programs six percent (6%),
- Veterans Affairs three percent (3%)

Few commercial health insurance companies operate on the Island; as of 2014, only thirty-six percent (36%) of Puerto Ricans received health insurance through commercial insurers either by paying for it themselves or through employers.

In territories such as Puerto Rico, federal medical assistance percentage (**FMAP**)—the amount the federal government will contribute toward Medicare costs—had been capped at the lowest level, fifty-five percent (55%), while on the mainland FMAP is based on per capita income. If that rule applied in PR, it would qualify for the highest level of assistance, eighty-three percent (83%).[199] The Further Consolidated Appropriations Act, 2020 granted the Government of Puerto Rico $5.3 billion of Medicaid funding in federal FY2020 through FY2021 at a seventy-six percent (76%) FMAP. Other territories received a match rate of eighty-three percent (83%).[200]

In Puerto Rico, Medicaid eligibility is based on the commonwealth poverty level (**CPL**) which is roughly half the federal poverty level (**FPL**). The FPL factors in the cost of basic necessities; the CPL doesn't. So, US citizens in Puerto Rico receive significantly less help, while having a much higher cost of living. Puerto Ricans are also ineligible for supplemental security income (**SSI**), used to calculate disproportionate share (**DSH**) and uncompensated care payments to hospitals.

Puerto Ricans are ineligible for Medicare's low-income subsidy to pay for prescription medications. There is now only one (1) pharmaceutical wholesale distributor serving Puerto Rico, which in turn results in an absence of competition. Consequently, Medicare enrollees sometimes split pills, spread out dosages, or skip prescribed medications, which leads to complications of health issues and ultimately higher healthcare costs.

CMS Reform Efforts

In November 2019, the Center for Medicare and Medicaid Services (**CMS**) announced that it had finalized a payment plan to incentivize physicians to focus on coordinated care and patient outcomes rather than on fee-for-service treatments for people who are

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[199] Navigating Recovery: Health Care Financing and Delivery Systems in Puerto Rico and US Virgin Islands. Kaiser Family Foundation Issue Brief. Dec 2017.
[200] HOUSE MESSAGE ON H.R. 1865 – THE FURTHER CONSOLIDATED APPROPRIATIONS ACT, 2020, https://www.rpc.senate.gov/legislative-notices/house-message-on-hr-1865_the-further-consolidated-appropriations-act-2020

already ill.[201] The final rule, "increases in the importance of cost performance under the Merit-Based Incentive Payment System, which ties Medicare Part B payments to clinician quality and cost-effectiveness. It's supposed to promote clinicians' transition to value-based payments, which reward physicians for outcomes instead of the volume of services provided."

Also making an environment where specialists are invited to consult regularly for the most complete patient treatment would create a more robust medical system more likely to incentivize medical graduates to remain in Puerto Rico.

The Health Policy Center report noted other changes Centers for Medicare and Medicaid Services has made to boost Medicare payments in Puerto Rico including:

- Revising Puerto Rico's geographic adjustment for calculating FFS payments to physicians under Part B which sets payments at the national average because of a lack of accurate data on the cost of living in Puerto Rico.
- Revising the formula used to calculate DSH and uncompensated care payments to Puerto Rican hospitals that factors in residents' ineligibility for SSI payments.
- Adjusting the MA risk adjustment model to better account for limited FFS Medicare participation in Puerto Rico and the large proportion of Puerto Ricans who are dual eligible.

Other recommendations discussed included increased investments in prevention programs, increased investments in health information technology, the development of super-utilizer programs for individuals with chronic illnesses, and expanding the residency programs in the Puerto Rico medical schools.

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[201] Brady, Michael. "Cms Is Changing How It Pays Doctors To Coordinate Care." https://www.modernhealthcare.com/payment/cms-changing-how-it-pays-doctors-coordinate-care

Hazardous Materials Management Lifeline

Solid waste management is the top threat in the hazardous materials lifeline in that there is no comprehensive or future-looking plan to mitigate the risk. So critical has improved solid waste management become to the Island that in May 2020, the Puerto Rico Public-Private Partnerships Authority (**P3**) listed it as number four (4) among seven (7) "Potential Projects to Become Priority Projects."

Contributors and Mitigators of Instability for:
Solid Waste Management Sector

	Contributors	Mitigators
Local Planning and Regulation	• Solid Waste management is not handled on a regional basis with agreements between facilities. . • There are an estimated 300+ clandestine dump sites • Recycling culture is not strong. Public education and cultural influence could improve. • Around 30% of compostable material is disposed as waste instead of being composted. • Most municipios (~80% are not currently engaged in recycling of compost material.	• Trainings and Certifications are issued to staff in Municipal Solid Waste program • Municipios are required by law to have a solid waste and recycling coordinators. Citation 411 requires this. Sanitation Law Reduction & Recycling Plan. • integrate solid waste management among regions to support redundancy and agreements for disposal of hazardous materials
Structure and Infrastructure	• The lack of modern/properly lined landfills is most likely impacting water quality near the landfills. Another event could cripple the eleven (11) landfills that remain in operation, • Thirteen (13) of these facilities continue to operate under EPA closure orders. • Lifespan of landfills is estimated at 1 to 3 years.	• Thirteen (13) of these facilities continue to operate under EPA closure orders.
Natural Environment	• Clandestine and open dumps are vectors for the spread of disease and nuisances such as pests and odors. • High frequency of weather events generate excessive debris. Hurricane debris produced 12 million cubic yards.	
Education and Awareness	• The public needs education and awareness. General public does not currently separating construction and demolition materials for appropriate disposal methods. • Recycling programs are needed. Puerto Rico Waste Generation Rate was 5.56 pounds per person per day. • Lack of attention to solid waste management is an impending health crisis for the Island.	• Comerío recycling program is a model – promotes recycling culture, has partnership with private company.

The Puerto Rico Solid Waste Authority identified a total of twenty-eight (28) landfills and dumps, including eleven (11) lined landfills and seventeen (17) open dumps. Thirteen (13) of these facilities continue to operate under EPA closure orders. The solid waste management system also includes seventeen (17) publicly owned transfer stations, nine (9) publicly or privately-owned materials recovery facilities, and four (4) publicly owned compost facilities. In 2010, before the hurricane event generated excessive debris, the

PRPB estimated that the Puerto Rico Waste Generation Rate was 5.56 pounds per person per day.

Hurricane debris produced 12 million cubic yards of debris disposed of in landfills and clandestine dump sites around the Island. The generation of post-storm debris (including vegetation such as fallen trees) as solid waste drastically shortened the lifespan of municipal and private waste management facilities. Lifespan of landfills are presently estimated at one (1) to three (3) years or less if the Island faces more disaster-caused debris. Another event could cripple the eleven (11) landfills that remain in operation, prolong the use of unlined open dumps, or possibly lead to more clandestine dump sites.

Solid Waste Management Needs

Lack of attention to solid waste management is an impending health crisis for the Island. Leachate and other run-off from facilities poses threats to water quality and human health. Improper management of methane gas can diminish air quality and, in some instances, pose a threat of explosion. Open dumps, especially, attract other vectors, which can endanger human health and degrade environmental conditions.

Management of solid waste infrastructure, services, and protocols is handled by a mix of public and private entities, each with separated roles in the management of the solid waste stream. For example, municipalities are required by law to have solid waste and recycling coordinators, but are not otherwise set up to interface and solve problems with key innovators that can bring recycling and composting solutions to the everyday lives of Puerto Rican citizens.

These issues are exacerbated immediately following a major disaster by the need to clear and remove debris quickly; the lack of clarity in appropriate roles and authorities among state, local and federal government; and the rise in clandestine dumping. These impacts could be significantly mitigated by an integrated waste management system--especially one that noted the economic value of portions of the debris stream that can be separated for future use or reuse, such as concrete, metals, and hardwoods.

One (1) case study in Puerto Rico that demonstrates leadership by innovation is the Municipality of Comerío. Comerío is leading a recycling program supported by community outreach and social change that promotes a culture of recycling, and leverages a partnership with the private sector.[202]

A critically important first step to solve the immediate need is to form intergovernmental partnerships and support regional consortia. Through these alliances, an integrated solid waste management structure can be explored, agreed upon, and implemented.

202 Municipio de Comerío, Comerío Verde, que te quiero verde.

Safety and Security

Safety and Security personnel and facilities are essential for first response services in a disaster event. Due to the critical role of this lifeline in emergency management and response activities, the long-term mitigation needs considered for safety and security are in the form of planning, hardened infrastructure, and force equipment.[203]

When critical infrastructure fails and supply lines are disrupted, safety and security lifeline assets are activated. These services are essential for ensuring food, water, fuel, and medical equipment are delivered safely to citizens through supply chain routes.

Scarcity of fuel after hurricane events required increased security to circulate to critical facilities such as hospitals, and placed safety and security workers at an extremely high risk when facilitating transport. This workforce also experienced personal challenges and were faced with a decision to tend to their personal and family needs versus professional duties.

The COVID-19 pandemic has exposed weaknesses in the supply chain for protective gear and medical equipment for the safety and security personal deemed essential to the public health crises. Municipal police forces were forced to shut down during the COVID-19 pandemic due to safety issues caused by a lack of proper safety equipment and resultant illness among the members of the workforce.

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[203] Due to the emergency response nature of the Safety and Security lifeline, PRDOH did not complete an analysis of contributors and mitigators of instability as this lifeline has dedicated resources through Emergency Management programs.

ECONOMIC CONDITIONS

Puerto Rico's current economic situation is a culmination of decisions and actions that have taken place over decades. Previous federal interventions to help Puerto Rico were designed to provide rapid and sweeping solutions for pressing problems, but these solutions ultimately contributed to economic vulnerability and dependency, not resiliency or sustainability. For example, efforts to improve the lives of Puerto Ricans through industrialization required a massive increase in the amount of available electricity, for which a system of importing of fossil fuels was created. Puerto Rico has become dependent on this system, which is expensive and, threatens energy security. The grid system built to accommodate the import and distribution requirements proved fragile and vulnerable during Hurricanes Irma and Maria and its failure led to cascading failures in communications, healthcare, water, and other Lifelines. In another example, the federal government endeavored to increase employment on the island through tax cuts luring foreign investment to the island by promising corporations an exemption from Puerto Rican income taxes, property taxes, building permits, or federal income tax. "This platform model benefited multinational corporations greatly so that by 1982 Puerto Rico produced more than thirty percent (30%) of US chemicals, but this industry only accounted for 10% of employment in Puerto Rico (Dietz, 2003)".[204] according to research by the EPA, Office of Research and Development, National Risk Management Research Laboratory, Sustainable Technology Division.

This tax break, Section 936 of the Internal Revenue code, did not give local businesses the same benefits. While the corporations who came to Puerto Rico because of IRS 936 created jobs, job training, and opportunity in the short term, when the tax cut was repealed in 2006, many employers left the island, causing the number of jobs to plummet and leading to a mass exodus of the labor force to the contiguous forty-eight (48) states. As researchers said: "Influenced by the phase out of US tax breaks in 2006 without a viable economic development plan to offset the impact (U.S. Government Accountability Office, 2006) and the subsequent global economic crisis of 2008, Puerto Rico has been in recession for the last ten years under study (2003–2013). .... The island's financial crisis eventually led to a debt crisis that put Puerto Rico on course to default on its debts (Marans, 2016).".[205]

Today, federal assistance comprises a disproportionate amount of PR's economy. Eighty-five percent of the island's food is imported, though Puerto Rico has an ideal agricultural climate. Ninety-five percent of the island's fuel is imported fossil fuel, despite abundant sunshine, wind, water, and other natural resources commonly used in renewable energy.

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204 Alejandra M.González-Mejía, Xin (Cissy) Ma, et al. "The Emergy Perspective of Sustainable Trends in Puerto Rico From 1960 to 2013." *Ecological Economics*, US Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Sustainable Technology Division, 29 Nov. 2016. https://www.sciencedirect.com/science/article/pii/S0921800915302044

205 Marans, 2016 Alejandra M.González-Mejía, Xin (Cissy) Ma, et al. "The Emergy Perspective of Sustainable Trends in Puerto Rico From 1960 to 2013." *Ecological Economics*, US Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Sustainable Technology Division, 29 Nov. 2016. https://www.sciencedirect.com/science/article/pii/S0921800915302044

These researchers and others believe a sustainable economy requires policy, education, and institutional support of local business creation, innovation, and entrepreneurship that capitalizes on local resources. [206]

Demographics[207]

In the year 2010, before Hurricane Irma and María, the total population of Puerto Rico was approximately 3,725,789 with a median age of thirty-six point nine (36.9) years. Before the hurricanes in the year 2017, it was estimated that Puerto Rico had a population of 3,193,694 residents with a median age of thirty-nine-point four (39.4); a median age that is nearly two (2) years older than the median age in the United States thirty-seven-point nine (37.9).[208] The 2019 population reduction of approximately fourteen-point three percent (14.3 %) and the two-point five percent (2.5%) increase in the median average age illustrate a migration trend of the Island's youngest population, mainly to the US, which was accelerated by the Hurricane disasters on 2017.

Gender and Age Factors

The total female population of Puerto Rico in the year 2010, was estimated at 1,940,618, representing fifty-two-point one percent (52.1%) of the population of the Island. Puerto Rico is considered an aging Island. In 2019, it was estimated that twenty-point seven percent (20.7%) of the population was sixty-five (65) years or older. This aging trend in the demographics of the Island represents great challenges to planning efforts and disaster mitigation approaches.

Households

In 2010, the US Census Bureau estimated the number of households in Puerto Rico was approximately 1,376,531. In the period from years 2014 to 2018, the migration patterns of Puerto Ricans to the United States led to a reduction in the total number of households to approximately 1,205,075.

The average household size for 2010 was estimated at approximately two point six eight (2.68) people per household. However, despite the reduction in the number of households, the average household size increased to two point seven eight (2.78) people in the period 2014 to 2018. In 2010, the average family size in Puerto Rico was estimated at approximately three point one seven (3.17) people per family.

[206] Alejandra M.González-Mejía, Xin (Cissy) Ma, et al. "The Emergy Perspective of Sustainable Trends in Puerto Rico From 1960 to 2013." *Ecological Economics*, US Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Sustainable Technology Division, 29 Nov. 2016.. https://www.sciencedirect.com/science/article/pii/S0921800915302044

[207] . Alejandra M.González-Mejía, Xin (Cissy) Ma, et al. "The Emergy Perspective of Sustainable Trends in Puerto Rico From 1960 to 2013." *Ecological Economics*, US Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Sustainable Technology Division, 29 Nov. 2016. https://www.sciencedirect.com/science/article/pii/S0921800915302044

[208] Government of Puerto Rico. *Puerto Rico Disaster Recovery Action Plan for the Use of CDBG Funds in Response to 2017 Hurricanes Irma and María.* Government of Puerto Rico, Page 27, February 2020 (Amendment Three).

Median Household Income, Poverty Levels and Employment

The median household Income in Puerto Rico for the period that includes the years 2014 to 2018 was estimated at approximately $20,166. In contrast, the per capita income was estimated at $12,451 for year 2018 with approximately forty-three-point one percent (43.1%) of the total population qualifying for poverty status according to the Census.

Puerto Rico Unemployment Rate and Labor Participation				
Years	**2016**	**2017**	**2018**	**2019**
Unemployment Rate	11.8	11.5	10.3	8.5
Labor Participation	40.0	40.1	40.1	40.6
Source: Puerto Rico Planning Board, Economic Report to the Governor				

The unemployment rate in Puerto Rico in year 2016 was estimated to be eleven-point eight percent (11.8%), but trended lower in the following years. In 2017, the unemployment rate was estimated to be eleven-point five percent (11.5%) and reached a dramatic reduction in 2019, to eight-point five percent (8.5%). However, despite the reductions in the unemployment rate of Puerto Rico, the Labor Participation Rate remains steady, maintaining a slight increase at a forty percent (40%) rate of Labor Participation to forty-point six percent (40.6%) Participation Rate.

Economic Conditions

Gross Product

Gross Product (**GP**) is made up of domestic demand for goods and services, along with net sales from the rest of the world. For fiscal year 2010, Puerto Rico's GP totaled $64,294.6 million at current prices. It recorded a slight increase in the subsequent three (3) fiscal years (from period 2011 to 2013). In fiscal year 2014, the GP declined to $68,797.5 million due to the economic downturn of previous years and the high indebtedness of the Government sector, raising serious questions about Puerto Rico's future economic performance. However, despite the not-so-hopeful economic picture that foreshadowed the indebtedness of Puerto Rico's government sector, in 2015 the GP increased by one percent (1%) to record the total figure of $69,602.0 million. This pattern of slight growth in the GP continued in 2016 when the Gross Domestic Product (**GDP**) was $69,985.2 million.

Puerto Rico Gross Product (Fiscal Years 2010-2019) In Million Dollars									
2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
64,294.6	65,720.7	68,085.7	68,944.9	68,797.5	69,602.0	69,985.2	69,049.5	67,824.7	70,780.5
Source: Puerto Rico Planning Board, Economic Report to the Governor 2019									

In 2017, the GP shrank to $69,049.5, because of Hurricanes Irma and María. The following year, 2018, showed a dramatic reduction in the GP, to $67,824.7 million. However, 2019 saw an increase in the GP recording the amount of $70,780.5 million associated with the entry of federal funds assistance for the recovery from damage caused by Hurricanes Irma and María.

Gross Domestic Product

The GDP is a widely used economic indicator to monitor and analyze the economy of a given country. In 2016, Puerto Rico had a GDP of $104,336.7 million. The following year (2017), the Island GDP shrank to $103,445.5 million. The decrease in the GDP is associated with the aftermath of the hurricanes and the bankruptcy of the Puerto Rico Government sector. In 2018, the economic contraction patterns continued, recording another decrease in the GDP of negative two-point four percent (-2.4%) to a GDP of $100,978.9 million. Despite the previous economic contraction patterns of the GDP, Puerto Rico registered an increase in the GDP for year 2019, totaling $104,988.4 million, representing an increase of four percent (4.0%). This important increase in this economic indicator is associated with the granting of federal funds to aid recovery efforts.

Puerto Rico Gross Domestic Product (at Current Prices) in Millions				
Years	**2016**	**2017**	**2018**	**2019**
Total	104,336.7	103,455.5	100,978.9	104,988.4
Absolute Change			**Percentual Change**	
2018/2017	(2465.6)		2018/2017	(2.4)
2019/2018	4008.7		2019/2018	4.0
Source: Puerto Rico Planning Board, Economic Report to the Governor				

Personal Consumption Expenses

Another important economic indicator is Personal Consumption Expenses (**PCE**). This indicator includes expenses for food, medical and funeral services, and housing. In 2016 Puerto Rico's PCE was $60,979.4 million. This reflects sustained increases in the period from years 2016 to 2019. In 2017 PCE rose to $62,453.8 million. As mentioned above, this trend repeated itself in Puerto Rico in year 2018, to total a positive percentage increase of three-point eight percent (3.8%), or $2,395.0 million. In the following years this indicator continued its growth pattern, reaching $68,656.6 million in 2019; an increase of $3,807.8 million.

Puerto Rico Personal Consumption Expenses (at Current Prices) in Millions of dollars				
Years	**2016**	**2017**	**2018**	**2019**
Total	60,979.4	62,453.8	64,848.8	68,656.6
Dollar Amount Change			**Percentage Change**	
2018/2017	2395.0		2018/2017	3.8
2019/2018	3807.8		2019/2018	5.9
Source: Puerto Rico Planning Board, Economic Report to the Governor				

Government Consumption Expenses

The Government sector is one of the most important sectors in Puerto Rican economics. During the period from 2017 to 2018, the Government Consumption Expenses (**GCE**) decreased from $9,057.5 million to $8,052.8 million. This reduction is attributed to the factors associated with the disasters caused by the hurricanes, as well as the government reduction strategies imposed on the Government sector due the financial crisis and PROMESA.[209]

Puerto Rico Government Consumption Expenses (at Current Prices) in Millions of dollars				
Years	**2016**	**2017**	**2018**	**2019**
Total	8,603.7	9,057.5	8,052.8	9,774.7
Source: Puerto Rico Planning Board, Economic Report to the Governor 2019				

Gross Internal Investment

The Puerto Rico Gross Internal Investment (**GII**), decreased significantly from 2016, with $8,425.5 million to $8,062.7 million in 2017. However, the GII increased in the following years, attributed to the entrance of federal funds for the recovery of damages caused by the hurricanes. In 2018, the GII registered a total of $15,868.8 million, with a slight reduction to $15,299.0 million in 2019.

[209] Puerto Rico Planning Board, Economic Report to the Governor, 2019.

Puerto Rico Government Gross Internal Investment (at Current Prices) in Millions of dollars				
Years	**2016**	**2017**	**2018**	**2019**
Total	8425.5	8062.7	15,868.8	15,299.0
Source: Puerto Rico Planning Board, Economic Report to the Governor 2019				

Net Income to the General Fund

Puerto Rico Net Income to the General Fund (at Current Prices) in Millions of dollars				
Years	**2016**	**2017**	**2018**	**2019**
Total	9175.3	9334.9	9313.2	11375.9
Absolute Change			**Percentual Change**	
2018/2017	(21.7)		2018/2017	(0.2)
2019/2018	2062.7		2019/2018	22.1
Source: Puerto Rico Planning Board, Economic Report to the Governor 2019				

Creation of the Federal Oversight Management Board (**FOMB**)

In 2015, former governor Alejandro García Padilla officially declared that the Island would be unable to pay its $73 billion financial debt; it was also unable to pay nearly $50 billion in unfunded pensions. Puerto Rico is prohibited from filing for bankruptcy, by federal law. PROMESA created an independent oversight board responsible for restructuring the debt and overseeing negotiations with creditors. In addition, PROMESA established the FOMB for Puerto Rico to oversee the Island's budget and its fiscal plan.[210] PROMESA also:

- Created a seven (7)-member fiscal control board that would not be accountable to the Island government and would have control over Puerto Rico's budget, laws, financial plans, and regulations.
- Gave the board the power to force the Island government to balance its budget and force a restructuring with bondholders and other creditors if an agreement is not reached.[211]

[210] Public Law 114-187, 48 U.S.C. § 2101 et seq; known as The Puerto Rico Oversight, Management, and Economic Stability Act (PROMESA).
[211] Financial Oversight and Mgmt Board for Puerto Rico. "Home." *Financial Oversight and Management Board for Puerto Rico*, 4 Aug. 2020, www.oversightboard.pr.gov

Current and Future Economic Opportunity

Many experts have noted that Puerto Rico needs to build on its strategic advantages rather than rely on tax breaks and other incentives that aren't sustainable. This might include existing pharmaceutical and aerospace technologies; profitable crops including coffee—whose stores are threatened by climate change—and cannabis; green energy solutions such as resilient solar installations and capitalizing on other renewables; developing resiliency expertise to be deployed to other regions facing storms and natural disasters from climate change; ecotourism; and entrepreneurship.

Numerous accelerators around the Island could spur innovation and entrepreneurship including the Puerto Rican Ocean Technology Complex (**PROTech**).[212] and the Puerto Rican Solar Business Accelerator designed to do job training and help independent Puerto Rican solar installers begin operations. [213]

Many companies have produced innovations, particularly in response to the suffering following Hurricane María.[214] These include companies such as WATRIC Energy Resources that produces water from air and INSU Health Design that created a cooler to keep medicines refrigerated during prolonged power outages. These entrepreneurs are supported by companies like Morro Ventures, which launched a $20 million early-stage venture capital (**VC**) fund in 2019, to support Puerto Rico tech.

Pharmaceuticals

Prior to Hurricane María, more than forty-seven percent (47%) of Puerto Rico's Gross Domestic Product came from manufacturing and forty-two percent (42%) of that was biopharma.[215] Puerto Rico's life sciences sector includes twelve (12) of the world's twenty (20) top-grossing pharmaceutical companies (J&J, Roche, Pfizer, Novartis and Merck). Five (5) of the world's top ten (10) selling drugs in 2018, were manufactured on the Island (Humira, Eliquis, Opdivo, Enbrel and Xarelto). Internationally, eight (8) of the fifteen (15) top-selling biopharmaceutical products were made in Puerto Rico.[216]

In 2019, Puerto Rican pharmaceutical exports totaled more than $44 billion. Of that, $30.89 billion were exported to the US market, while $13.2 billion went to other countries, significantly more than any US state. Pharmaceutical exports comprise thirty percent (30%) of Puerto Rico's GDP, fifty percent (50%) of Puerto Rico's total manufacturing and thirty percent (30%) of manufacturing jobs.[217]

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212 "Puerto Rico Ocean Technology Complex (PROTech)." *DDEC*, .
213 "Puerto Rican Solar Business Accelerator." *The Solar Foundation*, www.thesolarfoundation.org/prsba
214 Rowley, Melissa Jun. "The Science, Tech & Art Revolution of Puerto Rico." Forbes https://www.forbes.com/sites/melissarowley/2020/03/03/the-science-tech--art-revolution-of-puerto-rico/#34cf2413514d
215 Government of Puerto Rico Department of Economic Development and Commerce. Puerto Rico Economy & Business Climate Overview. http://aaipr.upr.edu/wp-content/uploads/2017/05/2017-PR-Business-Climate-Presentation.pdf
216 Miller, Rodrick T. "Puerto Rico's Big Pharma Push." Industry Weekly. https://www.industryweek.com/the-economy/article/21132824/puerto-ricos-pharma-push
217 Miller, Rodrick T. "Puerto Rico's Big Pharma Push." Industry Weekly. https://www.industryweek.com/the-economy/article/21132824/puerto-ricos-pharma-push

While COVID-19 has had negative impacts on the economy of Puerto Rico, as it has elsewhere, it has exposed the risks brought by dependence on pharmaceuticals made in China and elsewhere abroad. This may provide an opportunity for Puerto Rico to rebuild its pharmaceutical industry to reduce that dependence.

MITIGATION PROJECT NEEDS

PRDOH conducted extensive outreach during the preparation of this original Action Plan in order to gain insight into community mitigation needs. These consultations, included meetings with PRPB, which is currently involved in the preparation of the municipal-level HMPs, under the FEMA HMA Program, and COR3 – which is the local agency with designated FEMA coordination authority and currently oversees the development of HMPs. COR3 is also the administering entity for Hurricane María HMGP, and houses the State Hazard Mitigation Officer (**SHMO**).

Because these funds are intended to mitigate against a multitude of risks rather than one (1) disaster event with a defined cost for recovery, stakeholder input on Puerto Rico's long-term mitigation needs became paramount to the planning process. As of August 14, 2020, PRDOH has conducted outreach to 150+ stakeholder entities which includes: 6 federal agencies, 120+ state agencies, sixty-two (62) municipalities and forty-five plus (45+) NGOs.

Stakeholder engagement was conducted during a time of ongoing activity under the Hurricanes Irma and María CDBG-DR program implementation, administered by PRDOH. Thus, PRDOH strategically engaged those entities with existing relationships formed during the hurricane recovery and offered new entities a chance to get involved by registering through the public website.

Leading up to the publishing of this Action Plan, PRDOH received one-hundred thirty-three (133) new registrants through the program webpage: eighty-one (81) entities, and fifty-two (52) private citizens (breakdown shown in the table below). PRDOH hopes to increase the number of registrants over time by leading an aggressive public information campaign leveraging the PRDOH website, social media, radio and television media.

CDBG-MIT Stakeholder Participation Registrants	
Type of Registrant	**# of Registrants**
Federal Governmental Agency	5
Municipal Governmental Agency	9
Non-Governmental Organization	7
Non-Profit Organization	20
Private, For-Profit Organization	24
Quasi-Governmental Organization	1
Resident of Puerto Rico (Private Citizen)	**52**
State Governmental Agency	15
Total	**133**

Stakeholder engagement has been a robust campaign to engage federal, state, municipal, and NGO participants. PRDOH provided information briefings early in the planning process and again once research concluded and the results of the Risk Assessment were made available to the public. During this time, PRDOH also held a series of roundtable discussions. Meetings taking place between the months of May and August are shown in the diagram below.

Roundtable discussions were held with a mix of state, federal, municipal, and NGO stakeholders to discuss various mitigation topics. The image below is a word map depiction of stakeholder comments from all roundtable sessions.

Stakeholder roundtable sessions revealed strong interest in "community-based" solutions for:

- Solid waste management
- Resource management
- Recycling
- Service to communities outside PRASA
- Landslides
- Schools (Community Services, Shelters, Etc.)
- Hospitals / Health
- Information systems
- Vulnerable Communities
- Need for "Capacity Building"

Figure 78. Word map of Stakeholder Roundtable Discussions

Results of Proposed Project Log

In May, PRDOH released the Proposed Project Log template[218] to federal, state, municipal, and NGO stakeholders to request a baseline understanding of mitigation project needs. As mentioned, because mitigation is a new program to address Puerto Rico's need to mitigate against a multitude of disasters rather than recover from one event, these Proposed Project Logs served as a basis for programs designed for this Action Plan. Proposed Project Logs profiled here have been submitted on or before September 15, 2020. PRDOH will continue to gather Proposed Project Logs through the public comment period.

Type of Entities	Total Entities	Total Requested Projects
Non-Governmental Organizations	15	336
Agencies	15	763
Municipalities	62	1209
Total	**92**	**2,308**

[218] PRDOH instructional video for how to complete the Proposed Project Log was released in July to increase awareness and support completion of the log by stakeholders. Video can be accessed here: https://www.youtube.com/watch?v=82lAUcQlyiw&feature=youtube

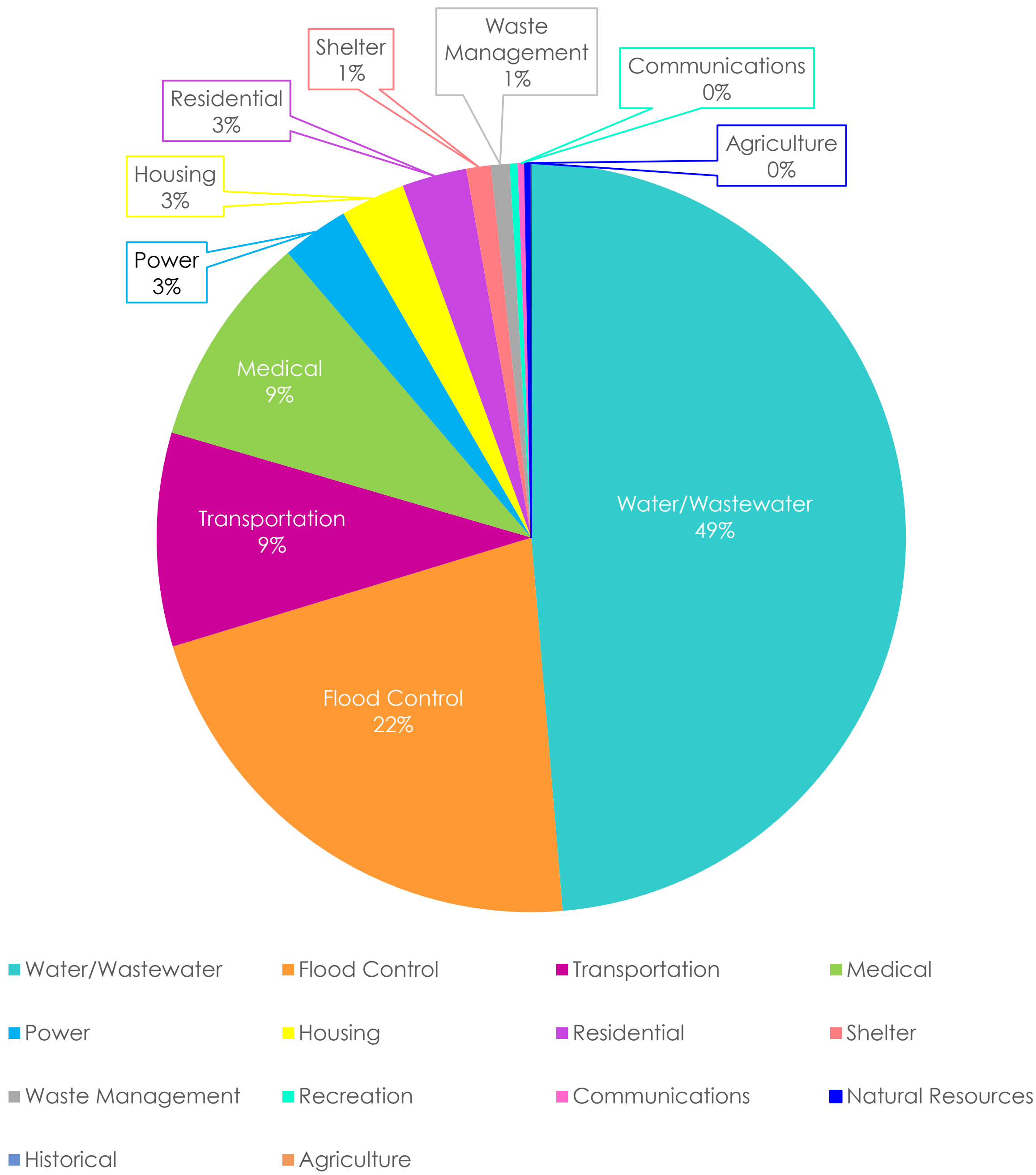
Stakeholder engagement thus far has produced over 2,300 requested projects totaling more than $18 Billion in estimated cost. The following tables and figures show a breakdown of supported lifelines, risk mitigated, and program budget need. Total cost shown in the tables may exceed the nearly $18 Billion in estimated cost of all projects received when projects benefit multiple lifelines or mitigate more than one risk category.

The table below and pie chart on the following page show the estimated project cost for proposed projects that support improvement to mitigate risk to FEMA lifelines. The top three (3) lifelines with respect to estimated project cost are: Water/Wastewater (49%), Flood Control[219] (22%), and Transportation (9.2%).

Estimated Cost and Percentage of Overall Cost of Lifeline Projects Submitted by Stakeholders		
Lifeline	**Estimated Cost**	**Percent of Total**[220]
Water/Wastewater	**$ 8,364,705,667.00**	**48.7%**
Flood Control	**$ 3,719,564,600.67**	**21.6%**
Transportation	**$ 1,585,319,209.00**	**9.2%**
Medical	**$ 1,584,136,914.32**	**9.2%**
Power	$ 498,174,230.00	2.9%
Housing	$ 479,352,404.00	2.8%
Residential	$ 479,352,404.00	2.8%
Shelter	$ 180,768,309.00	1.1%
Waste Management	$ 138,616,687.00	0.8%
Recreation	$ 57,865,330.52	0.3%
Communications	$ 55,145,000.00	0.3%
Natural Resources	$ 40,585,000.00	0.2%
Historical	$ 4,110,000.00	0.02%
Agriculture	$ 700,000.00	0.004%
TOTAL	**$ 17,188,395,756.01**	

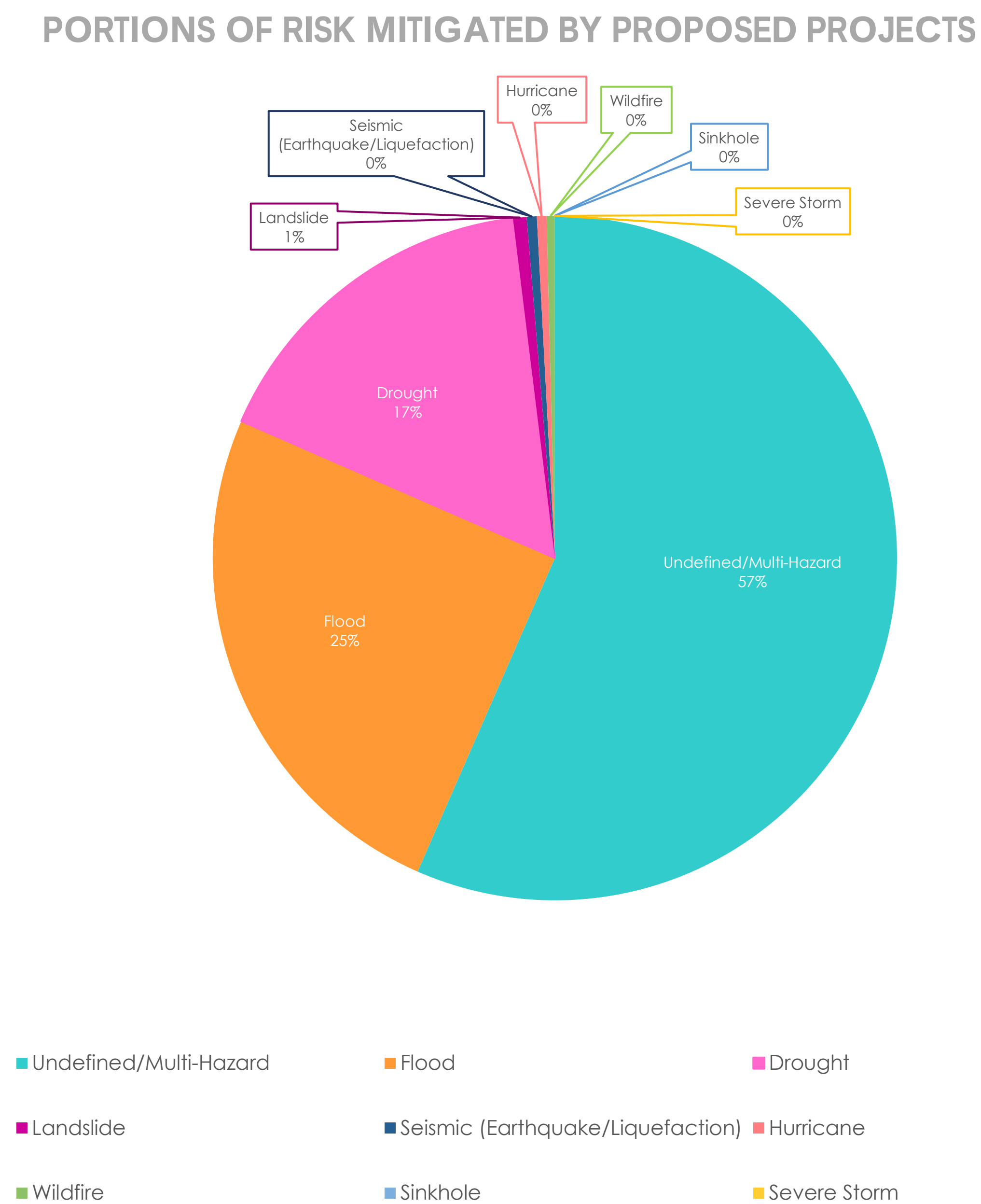
[219] Flood control is a subsector of the Community Safety sector of the Safety and Security lifeline but serves to mitigate risk to physical assets within all other lifelines.
[220] Projects that require additional information from the submitting entity in order to accurately determine the risk mitigated may not be included here.

LIFELINE PROJECT PORTIONS PROPOSED BY STAKEHOLDERS



The table and pie chart below show a portion of the proposed projects based on type of risk mitigated. The top three (5) risks mitigated with respect to estimated project cost are: Multi-Hazard Unidentified (57%), Flood (25%), and Drought (17%), Landslide (1%), and Seismic (Earthquake and Liquefaction) (1%). Multi-Hazard Undefined represents the projects that were submitted and classified as "Multi-Hazard" but require information in order to determine risk mitigation type.

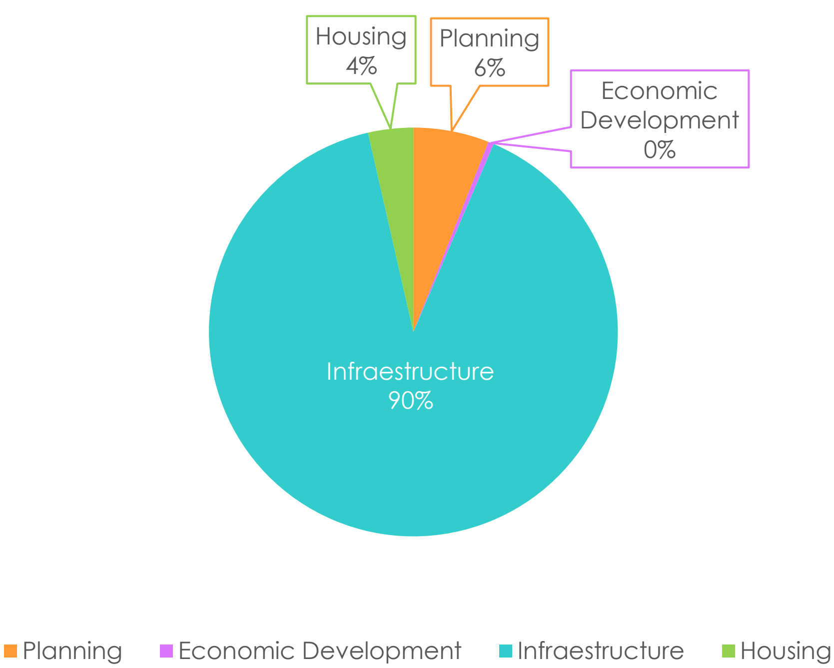
Estimated Cost and Percentage of Overall Cost of Risk Mitigated by Project Stakeholders		
Risk	**Estimated Cost**	**Percent of Total**
Multi-Hazard Undefined	**$ 9,914,975,899.89**	**56.6%**
Flood	**$ 4,377,772,730.19**	**25.0%**
Drought	$ 2,890,937,141.59	16.5%
Landslide	$ 111,691,277.50	0.64%
Seismic (Earthquake and Liquefaction)	$ 83,480,000.00	0.48%
Hurricane	$ 79,998,400.00	0.46%
Wildfire	$ 67,100,000.00	0.38%
Sinkhole	$ 500,000.00	0.003%
Severe Storm	$ 190,000.00	0.001%
TOTAL	**$ 17,526,645,449.17**	


PORTIONS OF RISK MITIGATED BY PROPOSED PROJECTS
Hurricane 0%
Wildfire 0%
Seismic (Earthquake/Liquefaction) 0%
Sinkhole 0%
Severe Storm 0%
Landslide 1%
Drought 17%
Undefined/Multi-Hazard 57%
Flood 25%
Undefined/Multi-Hazard
Flood
Drought
Landslide
Seismic (Earthquake/Liquefaction)
Hurricane
Wildfire
Sinkhole
Severe Storm

The table and pie chart below show the estimated program budget need based activity type of projects received form stakeholders. Programs in order from highest to lowest are Infrastructure (90%), Planning (6%), Housing (3.6%), and Economic Development (0.4%).

Estimated Program Budget Need Based on Projects Submitted by Stakeholders		
Program	**Estimated Cost**	**Percent of Total**
Infrastructure	**$ 16,397,226,682.73**	**90%**
Planning	**$ 1,092,661,562.44**	**6.0%**
Housing	$ 648,834,694.00	3.6%
Economic Development	$ 78,000,000.00	0.4%
TOTAL	**$ 18,216,722,939.17**	**100%**

PORTIONS OF BUDGET NEED BASED ON PROJECTS POPOSED BY STAKEHOLDERS



This section of the Action Plan shall be amended at a later date to incorporate the results of additional stakeholder input gathered through the Service Provider Mitigation Survey[221], the Citizen Survey, and public hearing events.

[221] The Service Provider Mitigation Survey can be accessed at: https://survey123.arcgis.com/share/a117e3ba0a3f47b7b616407ae4235a11?portalUrl=https://arcgis.hornellp.com/portal

GENERAL PROGRAM REQUIREMENTS

GENERAL PROGRAM REQUIREMENTS

Puerto Rico's CDBG-MIT allocation of $8.285 billion represents fifty-two percent (52%) of the HUD CDBG-MIT portfolio, which is distributed between a total of eighteen (18) HUD grantees. Each grantee's allocation is based on the proportional share of total CDBG–DR funds allocated by HUD for all eligible disasters in 2015, 2016, and 2017. Puerto Rico, receiving the largest allocation due to the system-crippling damage caused by Hurricanes Irma and María, and as a result, has designed its CDBG-MIT program to be flexible in meeting the scaled needs of homeowners, communities, municipalities, and Government of Puerto Rico services providers.

This substantial grant has been allocated in the Federal Register Notice 85 FR 4676 written specifically for the Government of Puerto Rico to contain increased compliance measures based on HUD's assessed areas of grant management risk reduction. These additional requirements and layers of oversight translate into increased administrative and coordination responsibilities for PRDOH as the grantee.

HUD COMPLIANCE REQUIREMENTS

HUD National Objective and Grant Beneficiaries

As stated at 84 FR 45838, 45839, HUD recognizes that this first-time appropriation of mitigation-only CDBG funds may pose challenges to grantees in aligning their mitigation strategies and activities with their obligation to use most of their CDBG–MIT funds to benefit low- and moderate-income (**LMI**) persons and to use the funds in the most impacted and distressed (**MID**) areas resulting from a disaster.

HUD defines LMI as the following:

- low-income individuals have an annualized family income of less than fifty percent (50%) of the HUD area median income, and
- moderate-income individuals have an annualized family income between fifty percent (50%) and eighty (80%) of the HUD area median income.

Puerto Rico is a unique grantee in that the entire Island is a MID area as designated in Federal Register Vol. 83, No. 157 (August 14, 2018), 83 FR 40314, 40315.

PRDOH acknowledges these distinct requirements and has therefore designed the strategies and programs within this Action Plan to include the following national objective and beneficiary considerations:

- PRDOH will utilize the new urgent need mitigation (**UNM**) national objective criteria found at 84 FR 45838, 45839 that is applicable to CDBG–MIT funds only, which requires activities funded with the CDBG–MIT allocation to result in measurable and verifiable reductions in the risk of loss of life and property from future disasters and to yield community development benefits.

- PRDOH does not, at this time, intend to request a waiver permitting the use of the national objective criteria for elimination of slum and blighting conditions, as HUD has clarified at 84 FR 45838, 45857 that this national objective generally is not appropriate in the context of mitigation activities.
- PRDOH will prioritize assistance to benefit LMI persons and ensure a total of fifty percent (50%) of the overall CDBG– MIT funds result in a benefit to said persons. HUD acknowledges at 84 FR 45838, 45856 that the standard seventy percent (70%) target is likely to be difficult to reach when grantees are pursuing community-wide or regional mitigation measures to protect entire regions or communities regardless of income. HUD also acknowledges at 84 FR 45838, 45841 that HUD will include 50 percent of a grantee's expenditures for grant administration in its determination that 50 percent of the total award has been expended in the HUD identified MID areas. Additionally, expenditures for planning activities may be counted towards a grantee's 50 percent MID expenditure requirement, provided that the grantee describes in its action plan how those planning activities benefit the HUD identified MID areas.

PRDOH acknowledges HUD guidance requiring that fifty percent (50%) of all CDBG-MIT funds be expended in the areas identified by HUD as MID. In Federal Register Vol. 83 No.28 (February 9, 2018) 83 FR 5844, 5845.[222] HUD identifies all municipal jurisdictions in Puerto Rico as being MID.

Implementation Plan, Financial Management and Grant Compliance Certification and Capacity Assessment

PRDOH, in fulfillment with the requirement of submitting financial certification documentation required by section V.A.1.a. of the CDBG-MIT Notice, 84 FR 45838, as amended herein, and the implementation plan and capacity assessment required by section V.A.1.b. of the CDBG-MIT Notice, 84 FR 45838, has prepared and submitted, separate from this Action Plan, the following documentation:

1) CDBG-MIT Financial Management Grant Compliance Certification Checklist with its supporting documentation,
2) Implementation Plan Narrative and
3) Capacity Assessment.

All of these documents will be submitted as part of the 2020 PRDOH CDBG-MIT Implementation Plan submission.

Plans to Minimize Displacement and Ensure Accessibility

Every project funded in part or in full by CDBG-MIT funds, and all activities related to that project, are subject to the provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (**URA**), as amended and section 104(d) of the Housing and Community Development Act of 1974 (**HCDA**), except where waivers or alternative requirements have been provided by HUD. The implementing regulations for

[222] Puerto Rico most impacted and distressed spending targets for CDBG-MIT funds are also listed in Table 1 of 84 FR 45838.

URA are at 49 C.F.R. § 24, and the regulations for section 104(d) are at 24 C.F.R. § 42, subpart C. The primary purpose of these laws and regulations is to provide uniform, fair, and equitable treatment of persons whose real property is acquired or who are displaced in connection with federally funded projects. Additional modifications to increase accessibility for applicants or household members of applicants who have access and functional needs is an allowable part of the repair, reconstruction, or relocation assistance provided by the Program. Eligible applicants who require additional accessibility accommodations will be provided with accessibility options during the pre-construction meeting (for repair or reconstruction) or during the pre-award meeting (for relocation). Additional reasonable permanent accessibility options will be available to applicants if the applicant or a member of the household requires such accommodations. The costs associated with the accommodations may be considered in addition to the Program caps and evaluated for cost reasonableness. (The Uniform Relocation Act and Anti-Displacement Policy[223] as well as all General Policies are available in English and Spanish at https://www.cdbg-dr.pr.gov/en/resources/policies/general-policies/ and https://www.cdbg-dr.pr.gov/recursos/politicas/politicas-generales/.)

Applicant Communication and Application Status Updates

PRDOH and/or potential subrecipients or partners are required maintain adequate means of informing applicants on the status of applications for mitigation assistance at all phases of program activities. PRDOH employs multiple methods of communications to ensure applicants receive timely and accurate information regarding their applications. Methods of communications are standardized for each program and include, but are not limited to the PRDOH CDBG-MIT website, email address, telephone number, postal address, letters, and case managers. For applicant individuals, all communication protects the privacy of the applicant by strictly adhering to privacy procedures pertaining to publicly identifiable information (**PII**). PRDOH has established procedures for the protection of PII and requires adherence to PII Procedures, as well as mandatory training for all relevant staff and assists all subrecipients and partners as necessary in the implementation of equivalent PII protocols. Safeguards to protect PII are overseen by managers and directors on an ongoing basis for their respective program area and any irregularities are reported to the compliance officer for resolution.

When PRDOH accepts applications from potential subrecipients, the manner in which information regarding their application status is communicated depends on the program and entity type. Municipalities who are subrecipients of the CDBG-MIT Program are assigned two consistent points of contact from PRDOH. Contact with subrecipients that

[223] The URA and ADP Policy has been developed for CDBG-DR programs and will carry through into implementation of the CDBG-MIT Program.

are not municipalities is managed at the program-level. Specific methods for application status updates will be clarified in Program Guidelines.

In addition to program specific protocol for application status updates as published in Program Guidelines, applicants may contact PRDOH at any time to request information at the contact information below:

- Via telephone: 1-833-234-CDBG or 1-833-234-2324 (TTY: 787-522-5950)
  Attention hours: Monday to Friday from 8:00am-5:00pm
- Via email at: CDBG-MIT@vivienda.pr.gov – for all CDBG-MIT inquiries
- Online at: https://www.cdbg-dr.pr.gov/en/contact/ (English version)
  https://www.cdbg-dr.pr.gov/contact/ (Spanish version)
- In writing at: Puerto Rico CDBG-MIT Program
  P.O. Box 21365
  San Juan, PR 00928-1365

Benefit Cost Analysis for Covered Projects

HUD has created a new standard for the evaluation of larger-scale infrastructure projects by introducing the concept of Covered Projects. A Covered Project is defined as an infrastructure project having a total project cost of $50 million or more, with at least $25 million of CDBG funds (regardless of source (CDBG–DR, CDBG-National Disaster Resilience (**NDR**), CDBG–MIT, or CDBG)). Infrastructure projects that meet the definition of a Covered Project must be included in the action plan or a substantial action plan amendment.[224]

These projects are also required to demonstrate how the benefits of the Covered Project outweigh the costs. HUD guidance found at 84 FR 45838, 45851 states:

- Grantees and subrecipients may use FEMA-approved methodologies and tools to demonstrate the cost effectiveness of their projects. FEMA has developed the Benefit Cost Analysis (**BCA**) Toolkit to facilitate the process of preparing a BCA. Using the BCA Toolkit will ensure that the calculations are prepared in accordance with OMB Circular A–94 and FEMA's standardized methodologies.
- A non-FEMA BCA methodology may be used when:
  - (1) A BCA has already been completed or is in progress pursuant to BCA guidelines issued by other federal agencies such as the Army Corps or the Department of Transportation;

[224] Covered Projects will be selected based on criteria published in program guidelines (to be released at a later date after HUD approval of the Action Plan) and added to the Action Plan by a Substantial Action Plan Amendment. See definition of Substantial Action Plan Amendment in Citizen Participation section of this Action Plan.

- (2) it addresses a non-correctable flaw in the FEMA-approved BCA methodology; or
- (3) it proposes a new approach that is unavailable using the FEMA BCA Toolkit.

- In order for HUD to accept any BCA completed or in progress pursuant to another federal agency's requirements, that BCA must account for:
  - economic development,
    - community development and other social/community benefits or
    - costs and the CDBG–MIT project must be substantially the same as the project analyzed in the other agency's BCA.
- Alternatively, for a Covered Project that serves LMI persons or other persons that are less able to mitigate risks or respond to and recover from disasters, the grantee may demonstrate that benefits outweigh costs if the grantee completes a BCA as described above and provides HUD with a benefit-to-cost ratio (which may be less than one) and a qualitative description of benefits that cannot be quantified but sufficiently demonstrate unique and concrete benefits of the Covered Project for LMI persons or other persons that are less able to mitigate risks, or respond to and recover from disasters. This qualitative description may include a description of how the Covered Project will provide benefits such as:
  - enhancing a community's economic development potential,
  - improving public health, and/or
  - expanding recreational opportunities.

Protection of People and Property and Construction Methods

Quality Construction Standards

PRDOH will implement construction methods that emphasize quality, durability, energy efficiency, sustainability, and mold resistance. All elevation-eligible homes that are reconstructed in place will be designed to incorporate principles of sustainability, including water and energy efficiency, resilience, and mitigation against the impact of future shocks and stressors.

Residential and Infrastructure construction performed under the programs will adhere to the Puerto Rico Codes 2018, Regulation No. 9049, as adopted on November 15, 2018.[225] Exceptions may be reviewed on a case by case basis. Importantly, the Code includes requirements regarding earthquake loads. This is vital as Puerto Rico must build structures that are resilient not only for hurricanes and wind, but for seismic activity and other potential weather hazards as well. This is consistent with the goal of protecting people and property from harm; emphasizing high quality, durability, energy efficiency, sustainability, and mold resistance; supporting the adoption and enforcement of modern and/or resilient building codes and mitigation of hazard risks, including possible sea level

[225] Puerto Rico Codes 2018, Regulation No. 9049 can be found here: https://jp.pr.gov/Portals/0/Construction%20Code/ICC%20Codes/Puerto_Rico_Codes_2018.pdf?ver=2018-11-28-133126-680

rise, high winds, hurricane surge, and flooding, where appropriate; and implementing and ensuring compliance with the Green Building standards as follows.

The Green Building Standard means that PRDOH will require that all applicable construction meets an industry-recognized standard that has achieved certification under at least one (1) of the following programs:

(i) ENERGY STAR (Certified Homes or Multifamily High-Rise),
(ii) Enterprise Green Communities,
(iii) LEED (New Construction, Homes, Midrise, Existing Buildings Operations and Maintenance, or Neighborhood Development),
(iv) ICC–700 National Green Building Standard,
(v) EPA Indoor AirPlus (ENERGY STAR prerequisite),
(vi) the "Permiso Verde," or
(vii) any other equivalent comprehensive green building program acceptable to HUD. PRDOH will identify which Green Building Standard will be used in the program policies and procedures, as per HUD requirements.

Where feasible, Puerto Rico will follow best practices such as those provided by the US Department of Energy's Guidelines for Home Energy Professionals. For all reconstructed structures, this may require installed appliances to meet ENERGY STAR certification standards at a minimum.

Elevation Standards

Elevation is eligible through the Housing Mitigation Program and shall only be applied when it is required and determined feasible to mitigate future flood risk and protect federal investments. PRDOH will apply elevation standards for residential structures in flood hazard areas where the activity is determined feasible that require the lowest floor of the home to be raised at least two (2) feet above the one percent (1%) annual floodplain elevation, as outlined in the 84 FR 45838, 45864. PRDOH will document when elevation, as opposed to alternative strategies, is cost reasonable to promote a community's long-term recovery on a neighborhood or local government level.

Nonresidential structures must be elevated to the standards described above or floodproofed, in accordance with FEMA floodproofing standards at 44 CFR 60.3(c)(3)(ii) or successor standard, up to at least two (2) feet above the 100-year (or one percent (1%) annual chance) floodplain. All Critical Actions, as defined at 24 CFR 55.2(b)(3), within the 500-year (or 0.2 percent annual chance) floodplain must be elevated or floodproofed (in accordance with the FEMA standards) to the higher of the 500-year floodplain elevation or three (3) feet above the 100-year floodplain elevation. If the 500-year floodplain or elevation is unavailable, and the Critical Action is in the 100-year floodplain, then the structure must be elevated or floodproofed at least three (3) feet above the 100-year floodplain elevation. Critical Actions are defined as an ''activity for which even a slight chance of flooding would be too great, because such flooding might result in loss of life, injury to persons or damage to property.'' For example, Critical Actions include hospitals, nursing homes, police stations, fire stations and principal utility lines.

Operation and Maintenance Plans

Operation and Maintenance Plans

PRDOH will require all project applicants to include a narrative plan detailing all necessary resources for the operation and maintenance costs of projects assisted with CDBG-MIT funds. Any application for a project that has not completed engineering or architectural design shall include a narrative that addresses in a preliminary fashion, any anticipated local funding sources, local staffing, contractors, equipment, leasing costs, or cost of materials for the long-term operation and maintenance needs.

Any applications for projects that have completed design must include a complete operation and maintenance plan prior to award of funding. Conditions will be placed in Subrecipient Agreements to provide quarterly operational and maintenance plan cost reports to PRDOH for the life of the CDBG-MIT Program.

Subrecipients must specify in their operations and maintenance plan if any government resources including local funds will be required to support long-term operations and maintenance costs. If operations and maintenance plans are reliant on any proposed changes to existing taxation policies or tax collection practices, subrecipients must expressly include this in their plan and identify all relevant milestones.

Cost Verification Procedures

HUD requires grantees to assure that construction costs are reasonable and consistent with market costs at the time and place of construction. Cost reasonableness is described as the price that a prudent business person would pay for an item or service under competitive market conditions, given a reasonable knowledge of the marketplace.

Cost or Price Analysis

PRDOH standards for cost or price analysis are outlined in the PRDOH Procurement Manual for the CDBG-DR Program[226]. The procuring entity shall require assurance that, before entering into a contract, a contract modification, or a change order, the cost or price is reasonable. The method and degree of cost or price analysis shall depend on particular facts of each procurement process, but as a starting point, the procuring entity must complete an independent cost estimate for the work to be completed. Documentation associated with the elements used in the evaluation of cost or price will be maintained in the file. To determine cost reasonableness, a two-step process must be undertaken during the procurement: The term cost reasonableness is defined in 2 C.F.R. § 200.404, not to be confused with the terms cost or price.

[226] The PRDOH Procurement Manual for the CDBG-DR Program can be accessed here on the website: https://cdbg-dr.pr.gov/wp-content/uploads/2020/06/Proposed-Procurement-Manual-CDBG-DR-Program-1.pdf

- Step 1. Prior to receipt of bids, proposals or change order: The procuring entity must complete an Independent Cost Estimate (**ICE**) for every procurement that is in excess of the Small Purchase Threshold.
- Step 2. Prior to the award of a contract: The procuring entity must complete a cost analysis or price analysis to determine if the cost or price proposed is reasonable.

Independent Cost Estimate (ICE)

The ICE must establish the total estimated cost related to the execution of the Scope of Work. The ICE will consider separate cost elements, as applicable, dependent on whether a cost or price analysis will be performed. The ICE must be completed in the same manner as the cost or price is requested in the solicitation to allow for a comparison. The ICE must be properly supported by data and documentation, this may include commercial pricing and sales information adequate to evaluate the reasonableness of the cost or price, such as, contracts of similar scope and scale; average costs for similar work in the area; published cost from a national cost estimating database or construction estimating software; a catalog, or other evidence of the market price, or documentation showing that the offered price is set by law or regulation.

Cost Analysis

(a) Cost analysis is the evaluation of separate cost elements that make up the offeror's total cost proposal to determine if they are allowable, directly related to the requirement, and reasonable. Whenever a cost analysis is required, it shall be performed by the Procurement Division of the procuring entity.

(b) A cost analysis shall be performed in the following instances:

i. When supporting data for other commercially available items of similar products or services are not available.

ii. When negotiating with a sole source.

iii. When, after soliciting proposals or sealed bids, only one proposal or bid is received and it differs substantially from the ICE.

iv. When there is a contract modification or change order that changes the scope and impacts price, and there is no available data to support the cost or price.

A cost analysis is not required when the price can be established on the basis of catalog or market prices of commercial products or services, or when the price is established by law or regulation.

Whenever the procuring entity is required to perform a cost analysis, profit must be negotiated separately. To establish a fair and reasonable profit, consideration must be given to the complexity of the work to be performed, the risk borne by the contractor, the contractor's investment, the amount of subcontracting, the quality of its record of past performance, and industry profit rates in the surrounding geographical area for similar work.

(c) To perform a cost analysis, the procuring entity shall:

1. Verify the cost submitted, and review:

a. The reasonableness of the proposed costs, including allowances for contingencies if applicable. To be considered reasonable, proposed costs must meet three critical tests. The costs must be allowable, allocable, and reasonable in accordance with 2 C.F.R. § 200.403-405.
b. The necessity for proposed cost items. A cost may be allowable under the cost principles and even allocable to the type of work to be performed, but still not be necessary for the specific contract. The procuring entity may consult with technical assistants or program/user areas if it is not clear that a proposed cost aligns with the framework established under the ICE or the requested services.
c. The application of audited or pre-negotiated (e.g., by the Federal Government) indirect cost (e.g., overhead) rates, labor and fringe benefit rates, or other factors.

Price Analysis

(a) Price analysis is the evaluation of a proposed price without analyzing any of the separate cost elements that it is composed of.
(b) The procuring entity may use price analysis in the following instances:
   i. When supporting data for other commercially available items of similar products or services are available and/or when the price can be established on the basis of catalog or market prices of commercial products or services, or when the price is established by law or regulation.
   ii. When there is adequate competition, meaning that two or more responsible offerors are able to compete effectively and independently for the contract.
   iii. When there is a contract modification or change order that changes the scope and impacts price, and there is available data to support the cost or price.

Davis-Bacon and Related Acts, and Executive Order 2018-033

The Davis-Bacon Act of 1931 and Related Acts (**DBRA**), as amended, 40 U.S.C. §3141-3148, applies to contractors and subcontractors carrying out construction work under a contract in excess of $2,000.00 that is funded in whole or in part by applicable federal assistance. DBRA provides for the determination of prevailing wage rates and fringe benefits to corresponding PRDOH CDBG-DR programs, projects and activities. The higher prevailing wage rate between Federal Government and State must be adhered to and made applicable. Davis-Bacon also applies to residential construction which consists of projects involving the construction, alteration, or repair of eight (8) or more separate, contiguous single-family houses operated by a single entity as a single project or eight (8) or more units in a single structure. DBRA determines applicability of Davis-Bacon to Federally assisted construction contracts. The Housing and Community Development Act of 1974 (**HCD**), 42 U.S.C. § 5301 et seq., Section 110 of the Act, determines the DBRA applicability to CDBG-DR.

Davis-Bacon wages are "based on the wages the Secretary of Labor determines to be prevailing for the corresponding classes of laborers and mechanics employed on projects of a character similar to the contract work" in a local area. 40 U.S.C. § 3142. These wage determinations are set by the US Department of Labor (**DOL**) and are published online at https://beta.sam.gov/help/wage-determinations. Additionally, the reporting requirements per HUD and the U.S. Department of Labor regulations must be followed. This requirement also extends to subrecipients and contractors. Applicable programs and services must comply with DBRA through the submission of certified payroll records and interviews of prime and subcontractor laborers. The Davis Bacon and Related Acts Policy, as well as all General Policies are available in English and Spanish at https://www.cdbg-dr.pr.gov/en/resources/policies/general-policies/ and https://www.cdbg-dr.pr.gov/recursos/politicas/politicas-generales/.

PRDOH acknowledges the restriction at 85 FR 4676, 4680 against taking Executive Order 2018–033 into account for CDBG-MIT construction contracts entered into by PRDOH when determining whether a wage cost is reasonable under the factors at 2 § C.F.R. 200.404. PRDOH will make an independent determination that wages to be paid with grant funds are reasonable, using factors such as the prevailing wage established by the Department of Labor or other indicators of market wage rates for comparable labor in the geographic area, and the restraints or requirements imposed by such factors as sound business practices and arm's-length bargaining.

Special Case Panel

PRDOH has implemented a Special Case Panel Policy applicable to ongoing activities of PRDOH CDBG-DR programs, as detailed in the Action Plan, CDBG-DR Program Policies, Manuals, Guidelines and Standard Operating Procedures (**SOP**s). The process will be considered for applicants participating in a CDBG-DR or CDBG-MIT program with an exceptional circumstance, to address situations when a program representative or requestor identifies a condition that has not been contemplated in the program as eligible. This Policy sets forth PRDOH policy to contemplate special instances where the need to review special cases to guarantee CDBG-DR funds and programs help the identified and intended audience. PRDOH attempts to resolve such issues in a manner that is both sensitive to the applicant's needs and achieves a result fully compatible with the CDBG-DR Action Plan, applicable laws, regulations, and local codes and ordinances.

Broadband Infrastructure

Broadband infrastructure is a sector within the Communications lifeline which has been determined to be critical lifeline Infrastructure upon which the stability of other lifelines is dependent. Broadband expansion is an eligible activity under CDBG-MIT programs and shall be incentivized through program design and project evaluation criteria as described in the Mitigation Programs section.

Additionally, under CDBG-DR, projects are required to include installation of broadband infrastructure at the time of new construction or substantial rehabilitation for multifamily rental housing that is funded or supported by HUD.

PRDOH aims to narrow the digital divide in low-income communities served by HUD. Installing unit-based broadband infrastructure in multifamily rental housing that is newly constructed or substantially rehabilitated with or supported by HUD funding will provide a platform for individuals and families residing in such housing to participate in the digital economy and increase their access to economic opportunities.

- Projects are excluded from this requirement only if one (1) of the below exclusions can be documented and validated by PRDOH:
- The location of the new construction or substantial rehabilitation makes the installation of broadband infeasible;
- The cost of installing broadband infrastructure would result in a fundamental alteration in nature of its program, or activity, or in an undue financial burden; or
- The structure of housing, to be substantially rehabilitated, makes the installation of broadband infrastructure infeasible.
- While Projects are only required to include one (1) form of broadband infrastructure, it is recommended to install more than one form as this will promote competition among service providers on quality and price for residents.

Section 3 Compliance

As the recipient of HUD CDBG-DR and CDBG-MIT funding, PRDOH acknowledges and complies with Section 3 (24 C.F.R. Part 135.30) of the Housing and Urban Development Act of 1968, as amended (12 U.S.C.1701u) 1 which is intended to ensure that, to the greatest extent feasible, low- and very low-income persons receive benefits in employment and related economic opportunities when such opportunities are generated by funding from HUD. PRDOH complies with the requirement by encouraging economic opportunities for households who are recipients of government assistance for housing. PRDOH provides Section 3 technical assistance, employment opportunities, reporting tools and best practice guidance for (a) employment, training and (b) contracting opportunities for low- or very low-income residents in connection with covered construction and covered non-construction projects.

PRDOH makes policies and tools available to fulfill Section 3 participation for new hires, training, contracting and other economic opportunities for participation in federal contracting opportunities on its website located in English and Spanish https://www.cdbg-dr.pr.gov/en/section-3/ and https://www.cdbg-dr.pr.gov/seccion-3/.

Program Income

Puerto Rico anticipates it may generate program income as part of the activities allowed under this allocation. Should any funds be generated, recovery of funds including program income, refunds, and rebates will be used before drawing down additional CDBG- MIT funds. These amounts will be recorded and tracked in the accounting systems and recorded in the HUD Disaster Recovery Grant Reporting (**DRGR**) system. The DRGR system requires grantees to use program income before drawing additional grant funds and ensures that program income retained will not affect grant draw requests for other subrecipients. Subrecipients will be required to report program income quarterly and will be subject to applicable regulations from PRDOH and HUD directives. Retention of program income will be in compliance with any subgrant agreements.

Procedures to Ensure Timely Expenditures of Funds

PRDOH is committed to the responsible, efficient, and transparent administration of CDBG-MIT funds through the implementation of a financial management framework which properly organizes policy, procedure, practices, and systems necessary to uphold fiscal responsibility. PRDOH uses procedures, systems, and monitoring strategies that encompass innovation, reduce redundancy, and improve timely expenditure of funds. PRDOH establishes procedures to ensure the timely expenditure of funds in its CDBG-DR Cross-Cutting guidelines, and supplements Cross-Cutting requirements with program guidelines where appropriate.

Expenditures for the CDBG-MIT Program are predicted based on program design and the assumption that grant funds will be granted timely by HUD. Projected and actual expenditures will be monitored on an ongoing basis and tracked and reported on a monthly and quarterly cycle.

Procedure for Aging Payments

One of the ways the PRDOH CDBG-DR Finance Department ensures that timely expenditure of funds is taking place is by generating the exception report to capture open payments between **ninety (90)** to **one hundred eighty (180) days** of issuance, after the monthly reconciliation. The CDBG-DR Finance Department takes this data and communicates with the corresponding Program Area so that the correct program management staff follows up with the vendor(s).

Procedure for Invoice Payment

PRDOH systematically processes invoice payments substantially supported by documentation. Payments are made timely, no less than **thirty (30) days after** receipt and acceptance of material and/or services.

Procedures to Track Expenditures Each Quarter

The Quarterly Performance Reports Standard Operating Procedures standardizes the method for reporting progress on the grant and Disaster Recovery Grant Reporting (**DRGR**) system activities by quarter, on a cumulative basis. These reports are due no later than **thirty (30) days** after the end of the quarter and they summarize obligations, expenditures, drawdowns, and accomplishments for the activities identified in the DRGR Action Plans.

Quarterly Performance Reports (**QPR**s) are maintained and published for public transparency on the program website in English and Spanish at https://cdbg-dr.pr.gov/en/reports/ and https://cdbg-dr.pr.gov/reportes/.

Procedures to Monitor Expenditures of Recipients

Monitoring is the principal means by which PRDOH ensures that programs and technical areas are carried out efficiently, effectively, and in compliance with applicable laws and regulations. Monitoring aims to assist CDBG-MIT funded programs with improving performance, increasing capacity and avoiding or remedying instances of non-compliance. Monitoring is not limited to a one-time event, but is an ongoing process that assesses the quality of CDBG-MIT funded program performance over the life of the contract or subrecipient agreement and involves continuous communication and evaluation. PRDOH anticipates that the monitoring operations under CDBG-DR will scale to coincide with increase of program launch activities. These operations will similarly be increased as CDBG-MIT programs are developed and launched.

Through monitoring, PRDOH will actively track any stalled program expenditures and assess appropriately, the need to reprogram funds.

Fair Housing, Equal Opportunity, and Civil Rights Responsibilities

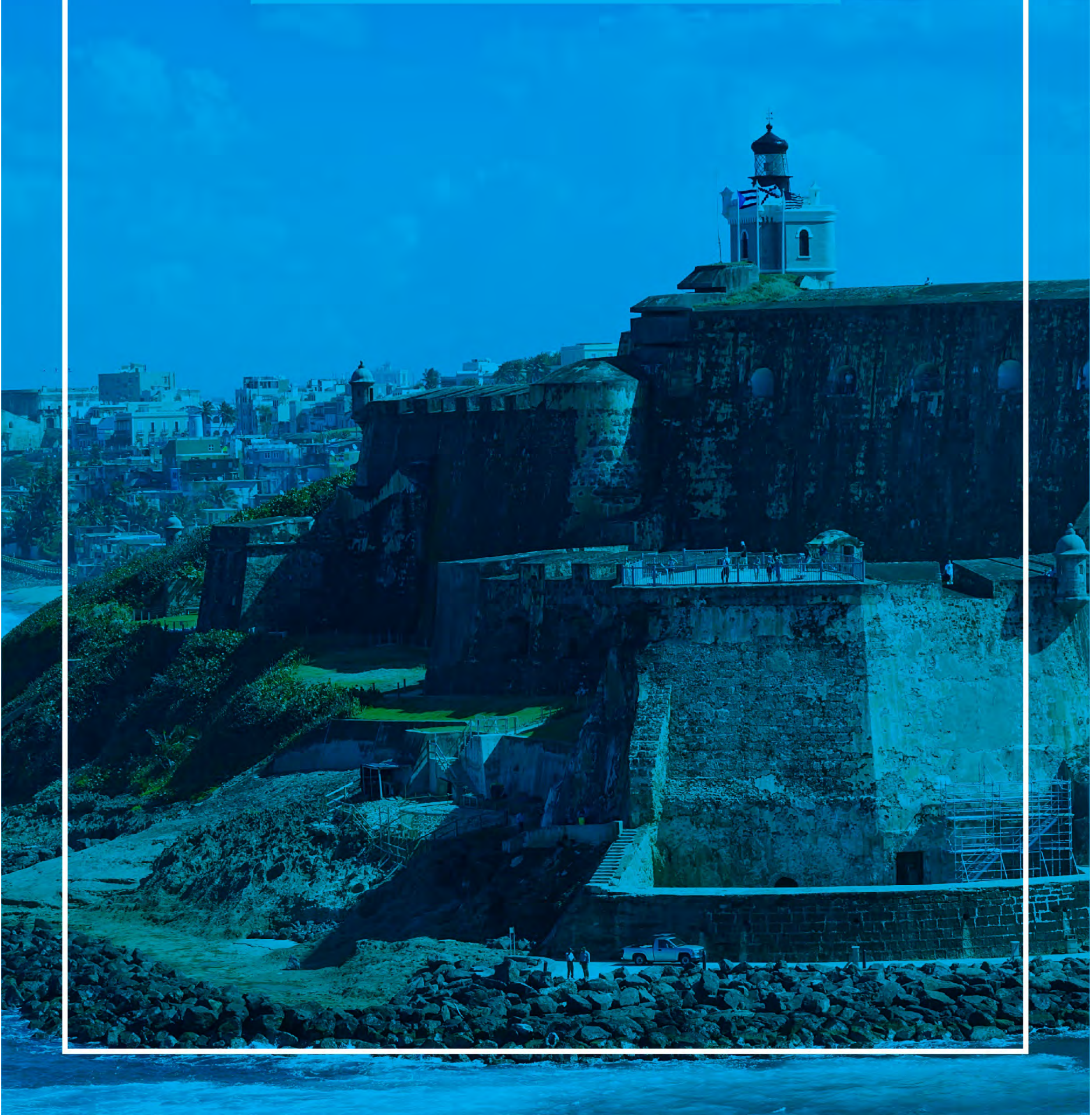
PRDOH, subrecipients, contractors and other program partners must comply with applicable federal civil rights, fair housing, and equal opportunity laws, statutes and executive orders. PRDOH will conduct regular training sessions for all CDBG-MIT staff, subrecipients, and contractors to ensure all parties understand and comply with relevant fair housing and civil rights requirements.

PRDOH is responsible for ensuring that programs are designed and implemented in a manner that complies with the requirements set forth in the Fair Housing and Equal Opportunity (**FHEO**) Policy for CDBG-DR Programs.[227]. (The Fair Housing and Equal Opportunity (FHEO) Policy for CDBG-DR Programs as well as all General Policies are available in English and Spanish at https://www.cdbg-dr.pr.gov/en/resources/policies/general-policies/ and https://www.cdbg-dr.pr.gov/recursos/politicas/politicas-generales/.)

PRDOH is available to provide technical assistance to any program office, subrecipient or contractor requesting support in ensuring that they are sufficiently complying with requirements to affirmatively further fair housing, provide equal opportunity, and comply with all civil rights requirements.

[227] The PRDOH Fair Housing and Equal Opportunity (FHEO) Policy for CDBG-DR Programs has been developed for CDBG-DR programs and will carry through into implementation of the CDBG-MIT Program.

MITIGATION PROGRAM



MITIGATION PROGRAMS

Alignment with HUD Policy Objectives

PRDOH envisions a resilient future for Puerto Rico that began with the initiation of the CDBG-DR portfolio and continues today through CDBG-MIT. HUD policy objectives for CDBG-MIT funds are stated in 84 FR 45838 as the following:

"CDBG–MIT funds represent a unique and significant opportunity for grantees to use this assistance in areas impacted by recent disasters to carry out strategic and high-impact activities to mitigate disaster risks and reduce future losses. While it is impossible to eliminate all risks, CDBG–MIT funds will enable grantees to mitigate against disaster risks, while at the same time allowing grantees the opportunity to transform state and local planning. Through this allocation for mitigation, HUD seeks to:

- **Support data-informed investments** in high-impact projects that will reduce risks attributable to natural disasters, with particular focus on the repetitive loss of property and critical infrastructure;
- **Build the capacity of states and local governments** to comprehensively analyze disaster risks and to update hazard mitigation plans through the use of data and meaningful community engagement;
- **Support the adoption of policies** that reflect local[228] and regional priorities that will have long-lasting effects on community risk reduction, to include the risk reduction to community lifelines such as Safety and Security, Communications, Food, Water, Sheltering, Transportation, Health and Medical, Hazardous Material (management) and Energy (Power & Fuel); and future disaster costs (e.g., adoption of forward-looking land use plans that integrate the hazard mitigation plan, the latest edition of the published disaster-resistant building codes and standards (to include wildland urban interface, flood and all hazards, ASCE–24, and ASCE–7 respectively), vertical flood elevation protection, and policies that encourage hazard insurance for private and public facilities); and
- Maximize the impact of available funds by **encouraging leverage, public-private partnerships, and coordination** with other Federal programs."[229]

Programs that Meet Risk-Based Needs

The programs defined in this section are informed by the Hazard Assessment, Risk Assessment and the Needs Analysis, as well as the unifying strategies described herein. They build on the work done under the CDBG-DR programs, and expand recovery efforts to include mitigation components. These programs are built on a foundation of data-

[228] PRDOH interprets the word local to mean municipal in this context.
[229] United States, Department of Housing and Urban Development, "Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees." 84 FR 45838 (August 30, 2019)

driven decision-making and sound planning, with policy and capacity building built into each Program.

Projects selected for funding through the CDBG-MIT programs shall serve the needs of the people by allowing for scaled investments that make critical mitigation dollars accessible to all communities on the Island: municipal, regional, or Island-wide. Programs in this Action Plan are designed based on precedent research, extensive stakeholder engagement, and an understanding of the planning and capacity building needs of Puerto Rican institutions and citizens. Included with the release of this Action Plan is a publicly available GIS tool containing the results of the data-based evaluation of risk down to the granular half mile hex grid level. The release of this tool makes available for the first time in Puerto Rico a common and transparent mapping of risk. This tool is intended to be a living database iteratively improved over time to carry into the future, while serving the immediate needs of the people with available dollars today.

The Risk Assessment results are available in the GIS tool shown here and can also be found as a link on the CDBG-MIT website in English and Spanish at https://cdbg-dr.pr.gov/en/cdbg-mit/ and [https://cdbg-dr.pr.gov/cdbg-mit/.](https://cdbg-dr.pr.gov/cdbg-mit/)

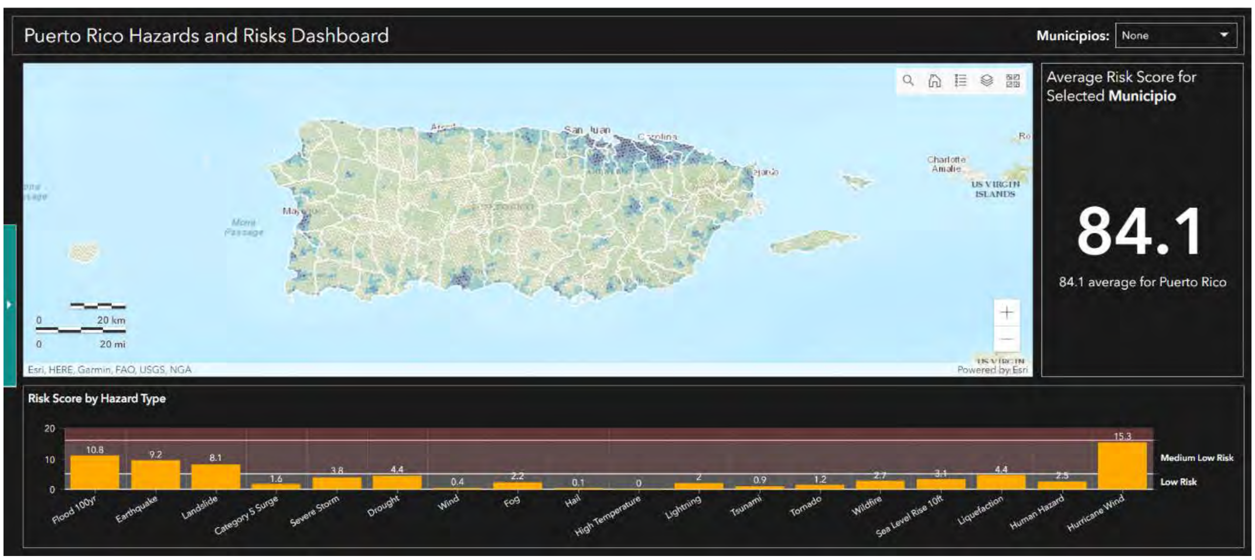


Figure 79.Image of the Puerto Rico Risk Assessment Dashboard Tool

Risk-Based Decision Making

Mitigation is an opportunity for Puerto Rico to change reactive disaster spending toward a data-supported, proactive investment in community resilience. The Risk Assessment completed for this Action Plan provides a sophisticated, up-to-date evaluation of the most common weather-related and human-caused risks that pose threat to Puerto Rico. It also increases the known risk of the hazards evaluated in the 2016 Hazard Mitigation Plan to include a broader understanding of the eighteen (18) evaluated hazards that pose a low-to-high risk to geographic areas across the Island.

This transparent dissemination of information is intended to assist all stakeholders in identifying areas of current and future risk and to provide insight for the development of projects that mitigate that risk, and to demonstrate the need for supportive policy change.

UNIFYING MITIGATION STRATEGIES

All projects selected for funding by the CDBG-MIT program must mitigate risk. This is defined by HUD at 84 FR 45840 as "… activities that increase resilience to disasters and reduce or eliminate the long-term risk of loss of life, injury, damage to and loss of property, and suffering and hardship, by lessening the impact of future disasters."

In addition, mitigation programs and supporting strategies have been developed in alignment with the spirit of HUD guidance to incorporate capacity building and coordination into proposed programs and projects by considering multiple perspectives before arriving at a funding decision. Specifically, 84 FR 45847 states that each grantee must describe how the proposed mitigation programs or projects will: (a) Advance long-term resilience; (b) align with other planned capital improvements; and (c) promote community-level and regional (e.g., multiple local jurisdictions) planning for current and future disaster recovery efforts and additional mitigation investments."[230]

Accordingly, PRDOH incorporates these requirements by evaluating the perspectives of the individual citizen, those citizens with an identified vulnerability to recovery, communities, and federal and state service provider stakeholders. These perspectives are all present in the strategic planning and oversight facets of the CDBG-MIT administrative structure and strengthen the programs through which mitigation projects will be funded.

PRDOH has identified four (4) unifying strategies built into the Mitigation programs to align with the coordination of mitigation projects and leverage requirements found at 84 FR 45847. These unifying strategies are woven into program design and incentivized through evaluation criteria, and supported by the development of capacity-building tools, including the Risk Assessment evaluation tool released during stakeholder engagement. These strategies include:

- **Capacity Building**: Make central the importance of continued planning, transparency of information and data sharing critical to emergency response and resilience; and increase the planning and implementation capacity for entities and citizens. A key component of increased capacity is also tied to the adoption of policies that reflect municipal and regional priorities with long-lasting effects on community risk reduction.
- **Community and Regional Investment**: Reduce the conditions of risk through community and regional level projects that identify transformative mitigation

[230] United States, Department of Housing and Urban Development, "Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees." 84 Fed. Reg. 169. (August 30, 2019)

opportunities that serve the needs of vulnerable communities and reduce the displacement of individuals.

- **Lifeline Stability and Strengthening**: Strengthen the critical lifelines through infrastructure improvements that prioritize water quality, and sustainability.
- **Alignment of Capital Investments**: Align CDBG–MIT programs and projects with other planned federal, state, regional, or local capital improvements.

These unifying strategies are further described in the sections that follow.

Capacity Building Strategy

Mitigation programs leverage the capacity structure PRDOH and subrecipients have built through the CDBG-DR Program, intentionally designed around the eligible activities of the CDBG regulatory framework. Mitigation includes an authorized planning and coordination component to ensure regional perspective, intentional lifeline strengthening, and upstream/downstream alignment.

The main objectives of the CDBG-MIT approach to building capacity are the creation of a stakeholder organizational infrastructure, mitigation policy and administration infrastructure, and a data collection and dissemination infrastructure. These capacity building strategies allow the entire community to make up-to-date, data-informed decisions regarding risk and hazard mitigation.

Through the planning programs described in this Action Plan, PRDOH will support the development of new or updated land use codes, building codes, and public planning policies and procedures that consider, facilitate, and address mitigation and risk reduction opportunities.

In addition, PRDOH will implement extensive public outreach and education through programs and shall utilize the Citizen Advisory Committee[231] to support the communication of the values and benefits of mitigation to stakeholders and the general public. This shall create an awareness and understanding of how mitigation investments can protect people, homes, neighborhoods, and critical lifelines to reduce risk to property and lives.

Through these efforts, Puerto Rico endeavors to incorporate hazard mitigation planning aspects into the public planning process and create a common understanding of risk and mitigation between citizens, elected officials, and public and private sector businesses, and support the development of a community of qualified mitigation professionals.

Capacity Building Coordination with Mitigation leaders

Successful implementation of mitigation capacity building strategies, and collaboration among stakeholders for CDBG-MIT, hinges on coordination with the Government of Puerto Rico mitigation leaders. To that end, PRDOH envisions forming a highly

[231] The Citizen Advisory Committee is a citizen advisory committee that has been formed under the CDBG-DR program and will be utilized to address both CDBG-DR and CDBG-MIT public information and citizen participation efforts.

collaborative and long-term partnership with the COR3 and the PRPB, to help create a modernized and robust approach to hazard mitigation, and to successfully build a comprehensive understanding and analysis of disaster risks. Such a robust understanding, coupled with access to hazard and risk data, serves to benefit all Puerto Rican communities.

It is the goal of PRDOH to leverage this coordination to expand the topics of discussion to include:

- Activities funded under CDBG-MIT, including enhancement of mitigation policy, planning, and capacity building activities;
- A summary of the status of the FEMA, USACE, EPA, USGS and other federal partners program/project funding and identification of their projects in the pipeline;
- The status of jointly funded COR3 and PRDOH infrastructure/mitigation programs and projects; and
- Opportunities to enhance or expand proposed projects that are mitigative in nature.

Community and Regional Investment Strategy

Transformative mitigation should look beyond man-made boundaries to consider geographic, ecological, and cultural characteristics. The CDBG-MIT program is designed with regional planning taking a central role in shaping data collection, capacity building, and project identification activities to support mitigation efforts. For example, flood mitigation efforts could be organized around watershed boundaries using regional stakeholder partnerships. Entities with jurisdiction over areas within a watershed could be grouped together to enhance awareness, coordination, and collaboration on flood mitigation efforts including, data collection, planning, capital investment, and building of capacity at the state and local level. Planning and Infrastructure programs within the CDBG-MIT portfolio prompt participants to submit, as part of their application, existing plans and evidence of planning efforts in order to ensure coordination of CDBG-MIT activities with existing plans.

CDBG-MIT programs also take into consideration existing municipal and regional planning efforts in their design. Mitigation planning coordination will take place over the course of the twelve (12) year grant to ensure alignment with planning under FEMA's HMA program, which occurs on a five (5)-year cycle, and the new Building Resilient Infrastructure and Communities (BRIC) program, which is in a pre-release phase that could impact disaster preparation and planning tied to mitigation.

As necessary, PRDOH will leverage the Citizen Advisory Committee to conduct stakeholder coordination meetings, during which opportunities for community and regional collaboration can be explored and program updates will be shared.

Lifeline Stability and Strengthening Strategy

Lifeline infrastructure, systems, and networks are complex and interdependent. Roles and responsibilities cross jurisdictional and sectoral boundaries. Lifeline infrastructure and, in particular, critical lifeline infrastructure in Puerto Rico, is owned by Government of Puerto Rico or municipal entities, private sector, and in some cases regional consortiums or NGOs. For this reason, PRDOH has designed Mitigation programs to enable funding for all sectors in a structure that rewards projects that mitigate the most risk for the highest number of beneficiaries possible.

To reduce hazard risks to lifeline infrastructure, PRDOH is setting a modern-day standard in risk assessment using transparent public tools. Through this increased planning capacity, applicant entities and Puerto Rico communities are able to evaluate in a common way, the risk factors and the costs and benefits of mitigation investments.

PRDOH also encourages program applicants and members of the Puerto Rican community to consider nature-based solutions, such as green infrastructure, for cost-effectively managing the impacts of natural hazards.

Alignment with Capital Investments

CDBG-MIT provides the greatest opportunity for alignment of capital investments on the Island in the following areas:

- **Mitigation Investment Coordination** – PRDOH Mitigation programs will leverage and coordinate mitigation investments by standardizing data collection and analysis on a regional basis and modernizing Puerto Rico's overall digital planning infrastructure and planning process to incorporate attributes related to risk. This modernization will allow data sharing and dissemination of risk information amongst federal and state agencies, local partners, and private sector investors.

- **Integration of Mitigation into Investment Decision Making** – Puerto Rico recognizes the need to integrate resilience and risk mitigation into the planning and decision-making process for capital investments, particularly infrastructure and buildings. As such, Mitigation programs offer funding to increase the use of financial instruments, and to create new approaches to investing in mitigation through incentives and additional risk transfer opportunities.

Puerto Rico is in the midst of an economic restructuring that has been most recently challenged by the interruptions of hurricanes, earthquakes, and COVID-19. Capital investments are now intertwined with recovery assistance and oversight from the FOMB. Per HUD requirements, FOMB has been asked to provide formal input on the CDBG-MIT Action Plan.

PRDOH's approach balances the goals of aligning mitigation policies across federally funded programs, maximizing efficiencies, and preserving critical aspects of the CDBG structure.

PRDOH has also considered how program and project needs align with economic recovery courses of action defined in the *Transformation and Innovation in the Wake of Devastation*.[232] economic report. This alignment is included in the Program descriptions summary at the conclusion of each section. Additionally, this CDBG-MIT Action Plan conducted extensive outreach and collaboration with a broad group of federal and state agencies, municipalities, private-sector, non-profit entities, and the group most affected by the hurricanes—the people of Puerto Rico. PRDOH met with many of the same contributor entities of the economic report and found that many of the needs identified for the plan in 2018, still remain.

METHOD OF DISTRIBUTION

PRDOH will utilize two (2) distribution models for its mitigation programs as shown in models A and B in the graphic below. These MODs shall be utilized to implement programs as outlined in detail within the program descriptions in the following pages.

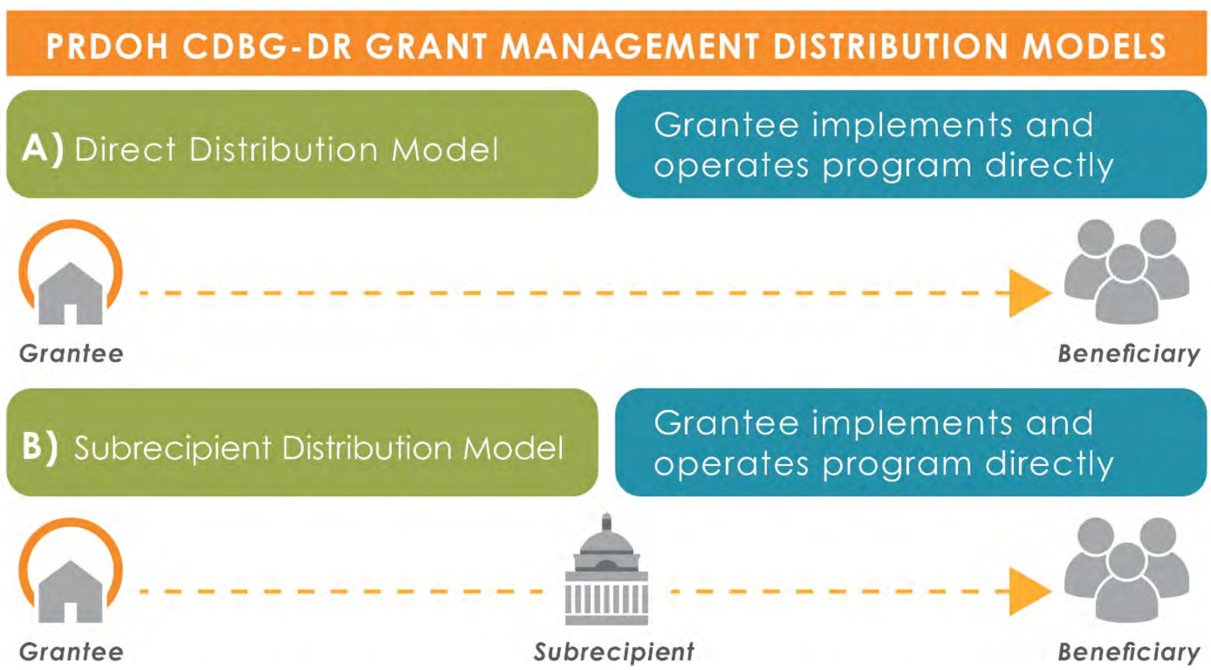


Figure 80.Method of Distribution models for PRDOH CDBG-MIT Programs

Municipalities and stakeholders will play an active role in many of the programs, including but not limited to housing and planning. Although regional collaboration is highly encouraged, for the purposes of duties and operations conducted under these programs, Partners and/or Subrecipients shall perform work only in their programmatic areas. Programs will be administered by PRDOH under one of these models:

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[232] Transformation and Innovation in the Wake of Devastation, an Economic and Disaster Recovery Plan for Puerto Rico. Government of Puerto Rico. August 8, 2018.

Grantee

The Government of Puerto Rico is formally the Grantee for the CDBG-MIT funds. The Governor has designated PRDOH as the grantee for purposes of administering the program and executing grant agreements with HUD. Therefore, PRDOH will be referred to as the grantee in this Action Plan and in administrative agreements with HUD.

Beneficiary

Beneficiaries are the persons to whom assistance, services or benefits are ultimately provided. Eligible beneficiaries are defined for each program in the Action Plan.

Subrecipients

Subrecipients are chosen by the grantee to undertake certain eligible CDBG activities. Subrecipient means a public or private nonprofit agency, authority, or organization, or a for-profit entity authorized under 24 C.F.R. §570.201(o), receiving CDBG funds from the recipient or another subrecipient to undertake activities eligible for such assistance. Subrecipients may include public and private organizations, agencies, including nonprofit and for-profit subrecipients, as applicable for the program established in the Action Plan. For-profits may only be included as subrecipients when assisting with economic development and micro-enterprise activities, unless otherwise waived by HUD. Subrecipients will meet the selection criteria outlined in the Action Plan and/or program guidelines and will:

- Carry out specified program on behalf of PRDOH
- Comply with all Federal statutes, regulations and program requirements
- Comply with all terms and conditions of the subrecipient agreement
- Meet all established performance goals

PRDOH is the responsible entity for subrecipient compliance and performance and Environmental Review under 24 C.F.R. § 58. Agreements with subrecipients will comply with 24 C.F.R. § 570.503. Therefore, Subrecipients who fail to meet any of the criteria outlined above, or as specified in their Subrecipient Agreement (**SRA**), may have their ability to carry out program activities rescinded, in which case, activities would be managed by PRDOH or its designee, or funds redistributed in accordance with the Action Plan.

PRDOH does not anticipate that any one subrecipients shall receive $500 million or more in grant funds to execute program activities. However, PRDOH acknowledges the requirements at 85 FR 4676, 4680 which state that a subrecipient without CDBG–DR or CDBG–MIT grant experience that are budgeted for activities equal to or exceeding $500 million, must adhere to a monitoring plan provided by PRDOH to HUD within ninety (90) days of the execution of the grant agreement. PRDOH acknowledges that in this event, it must provide a monitoring plan for overseeing the performance of other agencies, existing subrecipients, and subrecipients that will receive subawards (used here to mean grant funds provided to another agency of the Grantee or to a subrecipient) under the approved action plan for mitigation with dates and areas of review.

PROGRAM BUDGET

Program	Budget	Total	% Total Budget	% LMI Goal
PLANNING PROGRAMS		**$571,684,596.00**	**6.90%**	**N/A**
Risk and Asset Data Collection Program	$480,546,472.00			
Mitigation and Adaptation Policy Support Program	$24,855,852.00			
Planning and Capacity Building Program	$66,282,272.00			
INFRASTRUCTURE PROGRAMS		**$4,735,039,806.00**	**57.15%**	**50%**
Infrastructure Mitigation Program	$2,735,039,806.00*			
HMGP Match Set Aside	$1,000,000,000			
Healthcare Facilities Set Aside	$1,000,000,000			
HOUSING PROGRAMS		**$2,000,896,086.00**	**24.15%**	**100%**
Housing Mitigation Program	$2,000,896,086.00			
MULTI-SECTOR SUPPORT PROGRAMS		**$538,543,460.00**	**6.50%**	**0%**
Economic Development Investment Portfolio for Growth Program	$207,132,100.00			
Community Energy and Water Resilience Installations Program	$331,411,360.00			
ADMINISTRATIVE		**$ 414,264,200.00**	**5.00%**	**N/A**
Administrative Budget	$ 414,264,200.00			
Planning Oversight	$24,855,852.00	**$24,855,852.00**	**0.3%**	**N/A**
Total		**$8,285,284,000.00**	**100%**	**60%**

**Infrastructure Mitigation Program budget encompasses all project activity eligible under public facilities improvement.*

LMI Goal	Total	% of Total Budget
Programmatic LMI Goal	**$4,975,416,843.96****	**60%**

*** Calculation includes 60% of administrative and planning dollars assumed to benefit LMI in same ratio as project dollars.*

MITIGATION PLANNING STRATEGY AND PROGRAMS

Mitigation planning serves a primary purpose in identifying, assessing, and reducing the long-term risk to life and property from hazard events. PRDOH acknowledges this primary purpose by establishing a grant administration structure that makes central the role of planning in evaluating risk, mitigation opportunities, and projects, as well as ensuring project activities do not result in adverse upstream/downstream impact. Effective and continuous mitigation planning can break the cycle of disaster damage, reconstruction, and repeated damage.

PRDOH Planning programs balance the goals of aligning mitigation policies across federally funded programs, maximizing efficiencies, and preserving critical aspects of increased capacity realized over the course of CDBG-MIT funding.

Regional Decision-Making

Planning programs will be led by a multidisciplinary planning group within PRDOH led by the PRDOH Planning Director to serve as an oversight and coordinating body to tie together regional trends, partnerships, and research. The PRDOH Planning Group shall gather research and project data through stakeholder engagement planning efforts completed under programs such as the following:

- Municipal and Regional plans developed under Municipal Recovery Planning (**MRP**) Program
- Multi-jurisdiction or interagency plans
- Public-private partnership plans that advance regional solutions
- Federal and state agency plans that advance local partnerships and regional effort
- Community plans and strategies developed under the Whole Community Resilience Planning (**WCRP**) Program
- Municipal HMPs and BRIC plans
- Puerto Rico Geospatial Framework (**GeoFrame**) Program (formerly known as Agency Planning Initiatives/Geographic Information Systems (**API/GIS**))

The PRDOH Planning Group shall support the CDBG-MIT Program portfolio to make informed decisions that align regional investments where feasible. This coordination will take place in close collaboration with program staff implementing CDBG-MIT programs, especially the CDBG-MIT Infrastructure Mitigation Program and Mitigation Housing Program. This regionally-focused planning coordination component will build on and leverage the progress made through the CDBG-DR Planning programs.

PLANING SUPPORTED PROGRAMS

CDBG-DR PLANNING PROGRAMS	CDBG-MIT PLANNING PROGRAMS
GeoFrame Program Spatial Data Infrastructure (SDI) Plan Completed In Phase 1 Will Set Standards For Data Infrastructure, Collection, Cataloguing, And Maintenance. Web-Based Geoportal System Created In Phases 2 And 3 Will Establish The Information Architecture That Makes Data Available To The Public In User-Friendly Format.	**Risk & Asset Data (RAD) Collection Program** Data collection and maintenance must adhere to SDI Plan requirements as established under GeoFrame. Data collected will be housed in the Web-Based Geoportal developed by GeoFrame. RAD Collection will increase the types of data gathered and maintained for supporting informed mitigation decision making. **Planning & Capacity Building Program** Capacity building grants for the GeoFrame administering body to develop and implement policies, procedures, increase technical abilities of staff, execute data agreements, etc. **Infrastructure Mitigation Program** Support data-informed decisions regarding beneficiaries through knowledge of specific home and commercial property information. **Community Energy & Water Resilience Installations Program** The cadastral database that contains ownership and parcel registry data will be used to verify the legal and physical address associated with housing applications to support the detection and prevention of waste, fraud, and abuse. **Economic Development Investment Portfolio for Growth** Support data-informed decisions regarding beneficiaries through knowledge of specific home and commercial property information. **Housing Mitigation Program** The cadastral database that contains ownership and parcel registry data will be used to verify the legal and physical address associated with housing applications to support the detection and prevention of waste, fraud, and abuse.
Municipal Recovery Planning Program Spatial Data Infrastructure (SDI) Plan Completed In Phase 1 Will Set Standards For Data Infrastructure, Collection, Cataloguing, And Maintenance. Web-Based Geoportal System Created In Phases 2 And 3 Will Establish The Information Architecture That Makes Data Available To The Public In User-Friendly Format.	**RAD Collection Program** RAD Collection will supplement municipal data by filling gaps identified in planning. **Planning & Capacity Building Program** Capacity building grants to establish regional partnerships identified in MRP to strengthen solutions around watershed management, solid waste management, transportation systems, agricultural communities, and economic centers. **Infrastructure Mitigation Program** Projects identified in MRP can be put forth for funding and substantiated by plan. **Community Energy & Water Resilience Installations Program** Regional projects related to alternative energy and water resilience solutions at a community level can be put forth for funding and substantiated by the planning effort. **Economic Development Investment Portfolio for Growth** Projects identified in MRP can be put forth for funding and substantiated by plan. **Housing Mitigation Program** Repetitive loss or high-risk communities identified in MRP shall receive priority.
Whole Community Resilience Planning Program Identify Need Associated With Community Capacity Building & Regional Coalition Strengthening.	**Planning & Capacity Building Program** Capacity building grants to support need associated with community capacity building and identified opportunities to develop or strengthen regional coalitions. **Infrastructure Mitigation Program** Mitigation project needs identified during WCRP can be put forth for funding consideration. **Economic Development Investment Portfolio for Growth** Mitigation project needs identified during WCRP can be put forth for funding consideration.
Home Resilience Innovation Competition Program	**Community Energy & Water Resilience Installations Program** Models for home-based renewable energy and water storage may be considered once complete. **Housing Mitigation Program** Innovative home functions may be considered for reconstruction projects where feasible.

RISK AND ASSET DATA COLLECTION PROGRAM

RISK-BASED NEED: Puerto Rico is an Island located on an active fault line and directly in the path of hurricanes and tropical storms that move from the Atlantic Ocean into the Gulf of Mexico or the Caribbean Sea. It is subject to the increasing impacts of sea level rise and rising intensity of storms and weather events. Although the Island is vulnerable to a wide variety of hazard events, it does not currently hold or maintain comprehensive data related to lifeline assets, or the risks and hazards that could impact the social, ecological or built environment. While many of these datasets exist, they are held and maintained by different public and private entities with varying data standards. For this reason, access to these critical datasets are limited and, when available, often inconsistent between regions or entities; a challenge PRDOH encountered during the preparation of this original Action Plan.

Furthermore, during the preparation of the initial risk assessment, PRDOH also encountered a lack of consistency in the inclusion of US territory data as part of national and federally funded data sets. This lack of consistency and availability of data poses a challenge to entities trying to make risk-informed decisions. By centralizing and standardizing risk and asset data collection, PRDOH strives to reduce the administrative and burdensome cost of piecemeal and inconsistent risk analyses completed at the individual planning level. More importantly, standardization of data collection and study results will allow multiple stakeholders at all levels to utilize data for their specific purpose, while providing useful data for other stakeholders, thus creating a synergy that maximizes the benefits gained through collaborative data sharing. PRDOH also acknowledged that this data infrastructure should reside with a sustainable non-partisan institution dedicated to public transparency and data accessibility with adequate funding to ensure sustainability of the system into the future.

In the *Transformation and Innovation in the Wake of Devastation* Economic Disaster Recovery Plan[233], Puerto Rico identified eighteen (18) courses of action to support the goal of making high-quality data available to support better decision-making. These courses of action pertain to the creation of data management infrastructure, data gathering, data analysis, and transparent presentation of data for the benefit of a multitude of sectors and the general public. The estimated cost for these systems ranges from $978,100,000 to $1,749,400,000.

PROGRAM DESCRIPTION: The Risk and Asset Data (**RAD**) Collection Program will build on the foundation of the spatial data infrastructure created under the GeoFrame Program. This program will produce layers of hazard, asset, and risk data intended to complement the cadastral and land use data produced under the GeoFrame Program. It is intended to enhance the ability of citizens, private sector business and industry, mayors, governors

[233] Accessed at: https://recovery.pr/assets/documents/pr-transformation-innovation-plan-congressional-submission-080818.pdf

and other leaders to make data-driven decisions that are rooted in an up-to-date comprehensive understanding of hazards, risks, and assets on the Island.

This Program encourages a common understanding of how mitigation investments reduce risks to people, homes, neighborhoods, cultural and historic resources, ecosystems, and lifelines. HUD encourages grantees in 84 FR 45838, 45849 to use CDBG-MIT funds to upgrade mapping, data, and other capabilities to better understand evolving potential disaster risk.[234]

PROGRAM GOALS: The goal of the RAD Collection Program is to support the ability of citizens, private sector business and industry, mayors, governors and other leaders to make decisions informed by a geospatial understanding of hazards, risks and assets. Through extensive data aggregation and production, expansion of the GeoFrame Program Database, development and maintenance of critical data tools, and meaningful stakeholder outreach and engagement, the Program will increase transparency and existence of hazards, risks and assets, and empower stakeholders to invest their resources wisely.

For the purposes of this Program, the term "assets" refers to the critical social, ecological and technological assets that support a thriving community. These assets may be mitigative in nature, or they may be assets that need mitigation measures put in place. Social assets may include social services that assist individuals who have experienced disaster conditions, or cultural and heritage resources that must be located in order to be considered within a mitigation program. Ecological asset data collection and mapping would encompass, at a minimum, geolocation of industry requiring discharge permits, identification of natural resource areas or species protection zones, topographic mapping, and stream, river, and riparian zone modeling results. Critical assets also include more traditional technological (i.e. built environment) assets, such as location and attributes of transportation systems, water control structures, or communications infrastructure, among many others.

Protection and mitigation of communities require that existing assets are mapped and continuously updated with respect to the location, frequency, and magnitude of possible hazards and risks. Identifying the most appropriate location for a new public hospital, for example, demands that the administrators understand not only the medical needs of the area, but also the cause, location and severity of the risk, the attributes of the economic and built environment that increase vulnerability, the location, quality, and capacity of existing lifeline assets, and the projections and impacts of sea level rise.

To achieve this goal, the RAD Collection Program will use and expand the database standards and data collection, sharing, and mapping protocols developed under the CDBG-DR GeoFrame Program to include standards and protocols relevant to hazard, risk and asset layers. The program will fund the aggregation and production of existing and

[234] United States, Department of Housing and Urban Development, "Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees." 84 Fed. Reg. 169. (August 30, 2019)

new data related to past, present, and future hazards and risk and the location and status of social, ecological and built-environment assets. This data will be compiled into a database that merges with, or complements, the Spatial Data Infrastructure developed under the Geospatial Framework Program.

Furthermore, the program will fund the development, expansion, and/or maintenance of tools necessary for stakeholders to understand and use the data to make informed decisions. Two such tools to be expanded or maintained are the cadastral database and the Web-based Geoportal created under the GeoFrame Program. Both the Integrated GIS Database and the Web-based Geoportal depend on regular input of new land-based data as it is produced. As new hazard, risk and asset data is added, as structures are built, addresses assigned and parcels are subdivided or sold, and as land use changes over time, the Web-Based Geoportal and the underlying database must be updated and resolved.

The Program will also refine and make available the Risk Assessment Tool, initially developed for this Action Plan, to coalesce geospatial data assets that build upon the existing limited data infrastructure to more accurately and timely profile the location of housing, infrastructure, cultural assets, and social patterns and improve the understanding of risk from weather and human-caused events that threaten the Island. Public transparency of the data promotes not only awareness, but the opportunity for continuous refinement of data through formalized stakeholder engagement. Public benefits may also include a Hazard Early Warning System developed and housed in a transparent web-based location to offer a continuous feed from installed weather stations and river gauges to supply real-time data that alerts residents and emergency managers to rising flood levels through strategically placed stations and gauges.

This Program will identify viable funding sources and work towards securing funding to ensure longevity and financial independence. This independent funding is also intended to allow ongoing public access to data, databases and the Spatial Data Infrastructure developed under the GeoFrame Program, the RAD Collection, and other programs, as applicable.

Although the Program will be administered directly by PRDOH, it will depend on extensive stakeholder engagement and data sharing agreements. PRDOH embraces the opportunity to engage with relevant entities, as subrecipients, to execute portions of the Program based on their jurisdictional authority over the data being collected, or inherent strength in data management, or the underlying subject matter represented by the data.

Through the data and database production and development of tools, the RAD Data Collection Program is intended to inform current and future state and local hazard mitigation planning efforts, support critical investments by Government of Puerto Rico, local municipalities, businesses, and individuals, and dovetail with the GeoFrame Program and Title Clearance Housing Program, and others, as relevant.

PLANNING PROGRAM OUTCOMES:

OUTCOME 1: Data Aggregation and Production	
Hazard	PRDOH will collect data relative to Flood, Wind, Landslide, Earthquake and other hazard datasets as identified in the CDBG-MIT Hazard Analysis.
Risks	PRDOH will collect data relative to flood extent and probability, and other risks as necessary.
Communications System	PRDOH will collect data that will inform further analysis of the needs of an improved communications system.
Health and Medical System	PRDOH will collect data that will inform a Transportation Simulation Platform for efficient movement of patients and needed supplies across the Healthcare Network
Transportation System	PRDOH will assist with Geographic Information Mapping for the Puerto Rico Metropolitan Multi-Modal Mass Transit System. PRODH will assist with complete GIS Mapping of the Puerto Rico Highway Network
Energy/Power System	To be determined upon release of $1.93B in HUD funds for improvements to the power grid.
Water, Wastewater, and Stormwater System	PRDOH will collect data to support monitoring, maintenance and assessment of Water, Wastewater, and Stormwater System capacity and condition, identification of debris and blockages, and identification of illicit discharge points.
Social Service Resources	PRDOH will collect data to support coordination of social services that mitigate risk to residents of the island in the form of strengthened food distribution, emergency shelter, or medical services and partnerships, emergency response, and other service support systems.
Cultural Resources	PRDOH will collect data to support mitigation activities for the benefit of cultural resources from archaeology and historical properties to the visual and performing arts, museums, events, festivals and the creative industries.
Economic Resources	PRDOH will collect data to support sustainable, resilient economic development for Puerto Rico. This could include employment and workforce data for a variety of sectors, including construction, health and medical, renewable energy, energy efficiency, and others as deemed relevant.
Ecological Assets	PRDOH will collect data relative to locations and attributes of natural assets, including rivers, streams, riparian zones, topography, hydraulic capacity, soil types, flora, fauna, geologic assets, habitat, endangered and protected species, and/or others as necessary.
Environmental Discharge Sites	PRDOH will collect data relative to locations of public and private facilities that conduct activities that may affect the quality of air, water, soil and land. Data to identify illicit discharge sites.

Others as deemed necessary	
OUTCOME 2: Data Access, Analysis and Visualization Tools	
GeoFrame Database	PRDOH will support the expansion and maintenance of the GeoFrame Database.
GeoFrame Geoportal	PRDOH will support the expansion and maintenance of the GeoFrame Geoportal.
Risk assessment Tool	PRDOH will support expansion and maintenance Risk Assessment Tool, initially developed to inform the CDBG-MIT Risk Assessment.
Weather stations to collect weather related hazard data	Continuous data feed to the database and early warning systems that alert the public to hazardous conditions.
Flood gauges on major streams or rivers	Continuous data feed to the database and early warning systems that alert the public to hazardous flood conditions and could promote early evacuation.
Others as deemed necessary	
OUTCOME 3: Funding	
Identification of viable funding sources	Ongoing funding is necessary to support regular maintenance and refinement of geospatial data and tools.
OUTCOME 4: Stakeholder Engagement	
Stakeholder Engagement	Community coordination to support and coordinate data collection and gap analysis activities and increase public awareness of risk assessment tools and activities.

The need for other data sets and tools will become apparent as the RAD Collection Program is refined and developed through the Program Guidelines.

PROGRAM PHASING: The RAD Collection Program will launch immediately upon approval of the Action Plan and shall implement a phased approach to defining, collecting, developing, normalizing, publishing, and maintaining data and information assets gathered under this Program.

PRDOH will identify the most appropriate subrecipient(s) for ensuring the success and maintenance of this centralized database in perpetuity and to support risk identification and mitigation in the future and ensure federal investments are preserved. PRDOH will work with this entity or entities to identify what state and local resources are available for long-term operations and maintenance, and will address whether any proposed changes to existing budget appropriations, taxation policies, or tax collection practices will be needed to support the operations and maintenance costs. The use of CDBG-MIT funds for operations and maintenance will require a waiver from HUD.

ELIGIBLE ACTIVITIES:

- Section 105(a)(12) – Planning and Capacity Building
- Section 105(a)(14) – Activities Carried Out through Non-profit Development Organizations
- Section 105(a)(21) – Assistance to Institutions of Higher Education

INELIGIBLE ACTIVITIES:

- The use of CDBG-MIT funds for operations and maintenance cost is strictly prohibited unless otherwise permitted by a waiver from HUD.

METHOD OF DISTRIBUTION: Direct Distribution Model

ELIGIBLE ENTITIES: The RAD Collection Program will be administered directly by PRDOH. Data Sharing Agreements, Subrecipient Agreements, Interagency Agreements, or Memorandums of Understanding may be utilized to execute defined portions of this program; in those cases, program partners will be selected directly by PRDOH and must be one of the following:

- Units of general local government/ municipalities (including departments and divisions)
- Government of Puerto Rico Agencies, Authorities, Trusts and Boards
- Community-Based Development Organizations and private non-profits
- Non-governmental organization (501(c)(3)) or Not for Profit Entities

NATIONAL OBJECTIVE: N/A

MIN/MAX AWARD: PRDOH will directly administer or enter into an agreement with other Government of Puerto Rico entities to administer program activities on behalf of Puerto Rico for the benefit of all citizens. No awards will be made to beneficiaries.

ALIGNMENT WITH CDBG-DR PROGRAMS:

- Builds on the foundation of the spatial data infrastructure created under the CDBG-DR the GeoFrame Program.

ALIGNMENT WITH HUD POLICY OBJECTIVES:

- **Support data-informed investments** in high-impact projects that will reduce risks attributable to natural disasters with particular focus on repetitive loss of property and critical infrastructure.

- **Build the capacity of states and local governments** to comprehensively analyze disaster risks and to update hazard mitigation plans through the use of data and meaningful community engagement.

ALIGNMENT WITH ECONOMIC RECOVERY PLAN:

- **CIT 16** Government Digital Reform Planning and Capacity Building
- **CIT 17** Puerto Rico Data Center
- **CIT 18** Data Store and Data Exchange Standards for Critical Infrastructure
- **CIT 23** Data Collection and Standardization for Disaster Preparedness and Emergency Response
- **ECN 6** Improve Data Collection, Analysis, and Presentation
- **HOU 5** Collect, Integrate, and Map Housing Sector Data
- **HOU 6** Enforce Land Use Plans and Improve Compliance with Building Permitting
- **TXN 11** Support Infrastructure Asset Management
- **MUN 6** Create and Maintain Central Repository of Municipal Assets and Associated Conditions
- **NCR 1** Historic and Cultural Properties and Collections Preservation
- **NCR 26** Resource Management Capacity Building
- **NCR 28** Identify Funding for Natural and Cultural Resources Research
- **NCR 30** Create an Accessible Data Repository of Natural and Cultural Resources

MITIGATION AND ADAPTATION POLICY SUPPORT PROGRAM

RISK-BASED NEED: Mitigation activities to harden and modernize the built environment (i.e., the technological systems) to withstand hazardous events in the absence of policy support is an incomplete solution. True resilience is supported through the consideration and incorporation of the natural environment (i.e., ecological systems), and policy and governance structures (i.e., social systems) that impact human behavior. In addition, policies that result in mitigation are among the most cost-effective methods for enhancing resilience.

Centralized building code and land use plans in Puerto Rico are not restrictive of mitigation activities, but are hindered by a lack of modernization at the local level to ensure cohesion, enforcement, and granularity. The outcomes of the GeoFrame Program will increase mitigation adaptation efforts by delivering a cadastral database that enables an increased understanding of residents and housing stock in relation to geographic risks, as well as a publicly available mapping of land use plans. However, further information is needed through an objective and sweeping review of Puerto Rico's state and local policy and process, building code, land use plans, and zoning in relation to the updated Risk Assessment completed by PRDOH and in consideration of modernized mitigation solutions, green infrastructure, and benefits gained through the utilization and protection of natural resources.

PROGRAM DESCRIPTION: The Mitigation and Adaptation Policy Support Program builds on information related to policy needs across the Island collected through the stakeholder engagement process for this Action Plan, the Disaster Recovery Planning Programs, including the MRP Program, WCRP Program, and the GeoFrame Program. It shall also utilize, as it becomes available, the information collected under the CDBG-MIT Planning and Capacity Building and RAD Collection Programs.

Adaptation and policy support refer to the use of policy, building code, land use plans, zoning, and planning and capacity building interventions to enhance local jurisdictional and community ability to prepare and plan for, avoid, absorb, recover from, and more successfully adapt to potential risk from hazardous events. The evaluation of social structures, such as policy and governance of development in Puerto Rico, shall be based on the geographically based Risk Assessment completed and made available to the public, which yields an increased understanding of risk to integrate and align local, state, and federal policies that impact mitigation and long-term resilience in Puerto Rico.

The Mitigation and Adaptation Policy Support Program will further the policy-related goals identified by HUD in 84 FR 45838. The Federal Register seeks to support the adoption of policies that reflect municipal and regional priorities that will have long-lasting effects on community risk reduction and lessen the cost of future disasters. The Federal Register also encourages grantees to use CDBG-MIT funds to improve many of their governmental functions to better position jurisdictions to be more resilient in the face of future disasters.

A comprehensive policy analysis shall consider multi-hazard mitigation policy changes to create a policy framework that increases the adaptive capacity of local jurisdictions and neighborhoods including but not limited to[235]:

- **Limiting and preventing development in high hazard areas** such as: using conservation easements to protect environmentally significant portions of parcels from development; acquiring hazardous areas for conservation or restoration as a functional public park or natural mitigation asset; and/or acquiring safe sites for public facilities (e.g., schools, police/fire stations, etc.).
- **Adopting development regulations in hazard areas** such as: requiring setbacks from hazardous areas such as shorelines, steep slopes, or wetlands; requiring conditional or special use permits for the development of known hazard areas; adopting impervious cover limits; offering expanded development rights to developers/businesses for performing mitigation retrofits; and/or incorporating restrictive covenants on properties located in known hazard areas.
- **Limiting density of development in high hazard areas** such as: increasing minimum lot size for development; designating agricultural use districts; ensuring zoning ordinance encourages higher density outside of high risk areas; requiring clustering for planned unit developments in the zoning ordinance to reduce densities in known hazard areas; establishing a local transfer of development rights (**TDR**) program for risk in known hazard areas; and/or establishing a process to reduce densities in damaged areas following a disaster event.
- **Strengthening land use regulations to reduce hazard risk** through activities such as: using bonus/incentive zoning to encourage mitigation measures for private land development; using conditional use zoning to require mitigation measures for private land development; establishing a process to use overlay zones to require mitigation techniques in high-hazard districts; adopting a post-disaster recovery ordinance based on a plan to regulate repair activity; adopting environmental review standards; and/or incorporating proper species selection, planting, and maintenance practices into landscape ordinances.
- **Supporting local adoption and enforcement of building code** and inspections to help ensure buildings can adequately withstand damage during hazard events such as: adopting locally the requirements of Puerto Rico Codes 2018[236] standards and appropriate International Residential Code (**IRC**); incorporating higher standards for hazard resistance in the local application of the building code; considering the orientation of new development during design (e.g., subdivisions, buildings, infrastructure, etc.); establishing moratorium procedures to guide the suspension of post-disaster reconstruction permits; and/or establishing "value-added" incentives for hazard-resistant construction practices beyond code requirements.

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[235] Mitigation Ideas for Natural Hazards. FEMA. June 2017. Accessed at: https://prd.blogs.nh.gov/dos/hsem/wp-content/uploads/2019/05/R1_Mitigation-Ideas_June-2017.pdf

[236] Puerto Rico Codes 2018, Regulation No. 9049 can be found here: https://jp.pr.gov/Portals/0/Construction%20Code/ICC%20Codes/Puerto_Rico_Codes_2018.pdf?ver=2018-11-28-133126-680

- **Creating local funding mechanisms to leverage resources** through measures such as: establishing a local reserve fund for public mitigation measures; using impact fees to help fund public hazard mitigation projects related to land development (e.g., increased runoff); requiring a development impact tax on new construction to mitigate the impacts of that development; recruiting local financial institutions to participate in “good neighbor” lending for private mitigation practices; and/or providing a local match to federal funds that can pay for private mitigation practices.
- **Utilize incentives and disincentives to promote hazard mitigation** through measures such as: using special tax assessments to discourage builders from constructing in hazardous areas; using insurance incentives and disincentives; providing tax incentives for the development of low-risk hazard parcels and to encourage infill development; waiving permitting fees for home construction projects related to mitigation; using tax abatements, public subsidies, and other incentives to encourage private mitigation practices; and/or reducing or deferring the tax burden for undeveloped hazard areas facing development pressure.

PROGRAM GOALS: The goal of the Mitigation and Adaptation Policy Support Program is to enhance the mitigative efficacy of policies, programs, plans and projects across the portfolio of CDBG investments and other capital investments. Using a thorough stakeholder engagement process, political and regulatory analysis, and providing recommendations for new or enhanced processes or frameworks, the Program will improve the ability of state and local agencies to reduce risks and mitigate future damages from hazard events.

The Program will identify and analyze existing rules, laws, regulations, and policies that impact hazards, risk, mitigation, and resilience on the Island, and propose amendments to strengthen their mitigative and resilience impact. The Program will develop a policy toolbox that includes best practices, model ordinances, funding models, and other regulatory documents that can be adapted to local circumstances. The analysis will inform the Planning and Capacity Building Program of the possibility to fund inspectors.

PLANNING PROGRAM OUTCOMES:

OUTCOME 1: Municipal and Government of Puerto Rico Policy Framework Analysis and Recommendations	
Analysis	PRDOH and/or subrecipients will collaborate with relevant state and local entities to identify and analyze policies, procedures, incentives, codes or regulations pertaining to, or impacted by, current and future hazards identified as relevant in the Risk and Hazard Analysis. Topics of importance include land use, planning and zoning, development and building codes, code

	enforcement methods, transportation, and affordable housing, as well as others that may be identified as important during implementation.
Recommendations	PRDOH and/or subrecipients will work closely with relevant state and local entities to recommend adjustments to identified policies, incentives, codes and regulations, and tailor those regulatory tools to the needs and goals of the administering entity. Recommendations will be aimed at strengthening the resilience or mitigative value of regulatory tools and processes. One example of a proposed enhancement includes amendments to affordable housing policies to incorporate incentives pertaining to the location of affordable or subsidized housing outside of hazard zones and within proximity to lifeline assets.
OUTCOME 2: Policy Toolbox	
Best Practices	PRDOH and/or subrecipients will develop a suite of best practices related to Mitigation Planning, Programs and Projects. Best Practices will include regulatory or policy-oriented methods to enhance resilience for multiple scenarios. For example, the use of development restrictions in certain high-hazard areas or enhanced construction standards in other hazard areas.
Model Ordinances	PRDOH and/or subrecipients will develop model ordinances or regulatory tools to address specific identified mitigation or hazard concerns, including any trends identified during the Municipal and Government of Puerto Rico Policy Analysis. Model ordinances or regulatory tools should speak to issues relevant to multiple governmental entities or jurisdictions. They should be drafted with the flexibility to be tailored to the specific needs of the implementing entity, but should otherwise be a complete package that is ready to be adopted by each entity.
Relocation	PRDOH and/or subrecipients will develop policies that support the relocation of at-risk communities.
Increase Access to Insurance	PRDOH and/or subrecipients will develop model ordinances or regulatory tools to support actions that promote an increase in hazard insurance coverage.
Others as deemed necessary	

OUTCOME 3: Planning and Policy Integration and Alignment	
Resilience Scorecard	PRDOH and/or subrecipients will evaluate and communicate hazards and mitigation opportunities using a mitigation and/or resilience scorecard. The scorecard will be powered by the geospatial data collected under the CDBG-DR and -MIT data programs (GeoFrame and RAD Collection Programs).
Data Integration	PRDOH and/or subrecipients will work closely with relevant entities, including PRPB and municipalities, to integrate spatial data collected under the CDBG-DR and -MIT data programs (GeoFrame and RAD Collection Programs) into land use plans and zoning codes using the scorecard approach. The goal is to address hazards identified in the Mitigation Risk-Based Needs Assessment using spatially informed plans, policies and regulations.
Mitigation Plans	PRDOH and/or subrecipients will ensure the availability of geospatial data collected under the CDBG-DR and -MIT data programs (GeoFrame and RAD Collection Programs) for development, enhancements and updates to the State, local, or FEMA HMPs, or development of a FEMA-approved enhanced mitigation plan. PRDOH and/or subrecipients will also coordinate with HMP entities to support timely and current plans.
Plan/Policy Alignment	PRDOH and/or subrecipients will work towards alignment of multiple policies, procedures and plans into comprehensive framework that promotes a cohesive, Island-wide approach to mitigation. One example illustrating this need is that a hazard mitigation plan may call for acquisitions and buy-outs in high-hazard areas, while the comprehensive plan may set goals to increase investments in the same location.

The need for additional policy and planning support will become apparent as the Mitigation and Adaptation Policy Support Program is refined and developed through the Program Guidelines. This Action Plan description does not limit the program description.

PROGRAM PHASING: The Mitigation and Adaptation Policy Support Program will launch immediately upon approval of the Action Plan. Additional phasing of research and development of toolbox will be determined in collaboration with selected subrecipient(s).

ELIGIBLE ACTIVITIES:

- Section 105(a)(3) – Code Enforcement
- Section 105(a)(12) – Planning and Capacity Building

- Section 105(a)(14) – Activities Carried Out through Nonprofit Development Organizations
- Section 105(a)(21) – Assistance to Institutions of Higher Education

INELIGIBLE ACTIVITIES:

- Legislative lobby activities are prohibited.

METHOD OF DISTRIBUTION: Direct Distribution Model

NATIONAL OBJECTIVE: N/A

ELIGIBLE ENTITIES: The Mitigation and Adaptation Policy Support Program will be administered directly by PRDOH. Subrecipient Agreements, Interagency Agreements, or Memorandums of Understanding may be utilized to execute defined portions of this program; in those cases, program partners will be selected directly by PRDOH and must be one of the following:

- Units of general local government/ municipalities (including departments and divisions)
- Government of Puerto Rico Agencies, Authorities, Trusts and Boards
- Community-Based Development Organizations and private non-profits
- Non-governmental organization (501(c)(3)) or Not for Profit Entities

MIN/MAX AWARD: PRDOH will designate a lead partner entity that will administer program activities on behalf of Puerto Rico for the benefit of all citizens. No awards will be made to beneficiaries.

ALIGNMENT WITH CDBG-DR PROGRAMS:

- The Mitigation and Adaptation Policy Support Program builds on information related to policy needs across the Island collected through the CDBG-DR Planning Programs including the MRP Program, WCRP Program, and the GeoFrame Program.

ALIGNMENT WITH HUD OBJECTIVES:

- **Build the capacity of states and local governments** to comprehensively analyze disaster risks and to update hazard mitigation plans through the use of data and meaningful community engagement.

- **Support the adoption of policies** that reflect municipal and regional priorities that will have long-lasting effects on community risk reduction, including risk reduction to community lifelines such as Safety and Security, Communications, Food, Water, Sheltering, Transportation, Health and Medical, Hazardous Material (management) and Energy (Power & Fuel); and future disaster costs (e.g., adoption of forward-looking land use plans that integrate the hazard mitigation plan, the latest edition of the published disaster-resistant building codes and standards, vertical flood elevation protection, and policies that encourage hazard insurance for private and public facilities).

ALIGNMENT WITH ECONOMIC RECOVERY PLAN:

- **MUN 4** Build the Capacity of Municipalities to Apply for, Secure, and Manage Grants
- **HOU 6** Enforce Land Use Plans and Improve Compliance with Building Permitting
- **CIT 16** Government Digital Reform Planning and Capacity Building
- **CIT 23** Data Collection and Standardization for Disaster Preparedness and Emergency Response
- **CPCB 1** Disaster Preparedness Data Analysis and Decision Support Capability
- **CPCB 3** Capacity Building to Incorporate Hazard Risk Reduction into Planning and Design

PLANNING AND CAPACITY BUILDING PROGRAM

RISK-BASED NEED: Through stakeholder engagement during the development of the Action Plan, PRDOH received various requests from federal, municipal, and NGO stakeholders for funding opportunities and mechanisms to increase development capacity on the Island. . Most often, participants advocated that regional cooperation and coordination were the most effective means towards building the capacity needed to facilitate the implementation of mitigative activities.

This regionalized capacity building is intended to support local solutions. This includes, but is not limited to, localized policy and social mitigation solutions in that lead to extending of existing utilities, or alternative lifeline infrastructure, to ensure critical utilities and basic services reach underserved communities. Through sharing resources and minimizing costs, while avoiding duplicative or conflicting efforts, regional approaches serve to most effectively address shared mitigative needs. In order to achieve this goal, PRDOH will award project dollars that support the alignment of regional partnerships, shared resources, and community-strengthening support activities which also include adopting and enforcing up-to-date building codes, safeguarding lifelines and critical infrastructure, and using and expanding financial products and approaches that transfer and reduce risk.

PROGRAM DESCRIPTION: The Planning and Capacity Building Program will build on information and progress made through the CDBG-DR Planning Programs including the MRP Program, WCRP Program, and the GeoFrame Program. It will also utilize, as it becomes available, information collected under the CDBG-MIT RAD Collection Program. Finally, the program will continue and expand on stakeholder engagement to develop and implement a regional approach to planning, permitting, and enforcement that supports risk identification and mitigation.

The Planning and Capacity Building Program is intended to strengthen the capacity of state agencies, municipalities, NGOs and existing regional partnerships by assisting in the formation and/or strengthening and formalizing existing, regional consortia to conduct mitigation enhancing activities. These activities will range from narrow to broad. Some activities may include mitigation planning, green infrastructure education programs, emergency management training and demonstrations for building code compliance. Additional activities may include broad-based mandates such as furthering regional economic development planning, promoting safe and affordable housing, and assisting in access to private, state, and federal funding for activities that benefit the lifeline sectors, among others.

HUD emphasizes capacity building in 84 FR 45838 for multiple levels of government and the benefits of regional (multi-jurisdictional) planning and cooperation as a means for increasing capacity. The Planning and Capacity Building Program seeks to further those goals by supporting regional and multi-jurisdictional approaches to planning that enhances assessment and mitigation of risk.

PROGRAM GOALS: Through the Planning and Capacity Building Program, PRDOH will work directly with applicant entities to create formalized regional consortia or strengthen existing entities that provide increased development capacity on a multi-jurisdictional basis. The program will offer technical assistance by partnering with federal agencies, national associations and other organizations to provide educational and capacity building support services. This increase in capacity will benefit state agencies, municipalities, NGOs, planning and development organizations, and other public-serving entities and organizations in the evaluation and support of partnerships to promote mitigation.

Activities of regional cooperation that promote mitigation by strengthening lifelines can include, but are not limited to:

- Disaster and Mitigation Planning
- Economic and Community Development activities
- Housing
- Natural Resource Conservation and Protection
- Solid Waste Management
- Watershed Management
- Transportation and Transit
- Social Services

According to the Lincoln Institute of Land Policy, "Regionalism generally refers to ways of thinking and acting at the regional scale." As one example, the National Association of Development Organizations (**NADO**) states, "(N)atural disasters do not obey local jurisdictional boundaries. (R)egional hazard mitigation planning activities offer the benefit of pooling regional resources and developing a more integrated regional approach to disaster planning across jurisdictional lines."

Further, the benefits of regionalism can extend far beyond disaster planning and encompass a variety of other activities that contribute to an area's greater natural, economic, and social resilience. Again, according to NADO, such regional benefit can be achieved through the formal development of regional consortia, commonly known as Regional Development Organizations (**RDO**). "Known locally as councils of governments, regional planning commissions, economic development districts, and other names, RDOs provide various types of support to their member communities in a host of service areas. RDOs can open the door to grant and loan funding, provide administrative support, and supply valuable staff support and access to technology. For rural places, in particular, they can play a critical role in towns that may have limited capacity and resources."

Recognizing these benefits, the EDA is currently pursuing a pilot project to establish the first EDD in Puerto Rico. "EDDs are multi-jurisdictional entities…that help lead the locally-based, regionally driven economic development planning process that leverages the involvement of the public, private and non-profit sectors to establish a strategic blueprint (i.e., an economic development roadmap) for regional collaboration." While EDDs function as direct partners with EDA, EDA also has a current initiative to strengthen the capacities of municipalities to leverage and manage other federal grants, broadening the impact beyond their own funding opportunities. Finally, as noted by NADO above, EDDs are most often housed within, or take on the broader role of, an RDO.

Acknowledging the financial constraints expressed during the public engagement process, the Planning and Capacity Building Program will provide funding to support the formation and operation of a new consortium, or to strengthen the capacity of an existing consortium. Each awardee will be allocated a funding maximum to be expended over a **two (2)-year** time period for programs and capacity building proposals that will be evaluated on their mitigation merits and impact. Applications will need to be accompanied by an endorsement of the municipalities and participating entities in the proposed region.

PLANNING PROGRAM OUTCOMES:

OUTCOME 1: Increased Regional Capacity through Multi-jurisdictional Solutions	
Facilitate Intergovernmental Cooperation	Subrecipients will perform a detailed analysis of existing public partnerships and identify opportunities for multi-jurisdictional approaches to issue resolution. This includes identification and establishment of roles and responsibilities, including responsible parties, necessary to implement a regional approach to planning and permitting that enhances the ability of the community to identify, track, and mitigate risk.
Development of Regional Consortia	Subrecipients will capitalize on existing efforts to establish regional entities, utilizing established models of regional organizations. These could potentially include RDOs, leveraging the current pilot project by the EDA to establish EDDs in Puerto Rico, and/or strengthening regional partnerships or consortiums identified through the MRP Program. The Planning and Capacity Building Program will provide funding for staff of local, regional, or state entities to form regional partnerships or strengthen interagency coordination with the goal of creating an impact on disaster risk reduction and mitigation. These activities could include hosting stakeholder meetings and roundtables, organizing listening sessions, and identifying common issues with regional solutions.
Mitigation Activities of Regional Consortia	Through Regional Consortia, PRDOH will support opportunities to fulfill stakeholder requested capacity-building needs including but not limited to: Funding for staff to implement a regional solid waste program, activities for landfill permitting, landfill inspections, and/or implementation of the Integrated Solid Waste Management Plan.

	Funding for compliance training and enforcement of activities required for Consent Decree Case 3:14-cv-1476-CCC for violations of the Clean Water Act (CWA) and MS4 Permit. Build a workforce for shared needs such as code enforcement activities. Consider the potential for other shared-staffing needs identified through the public engagement process.
OUTCOME 2: Support and Integrate Hazard Mitigation Planning	
FEMA Hazard Mitigation Planning	Allow for planning match opportunities, where needed, in support of the five (5)-year mitigation planning cycle under FEMA's HMA program.
FEMA Building Resilient Infrastructure and Communities Planning	Allow for planning match opportunities as the new FEMA BRIC comes online.
OUTCOME 3: Training and Technical Assistance	
Enforcement	Supportive education and compliance activities to increase compliance with code requirements while reducing the penalty costs associated with non-compliance.
Awareness	Building local knowledge on the impact of activities that may affect air, water, land use and quality in Puerto Rico, can help state agencies and municipal governments identify risks, support and inform emergency preparedness, and response, municipal and Island-wide recovery, mitigation, and economic development planning efforts. Public outreach and education for the development of a sustainable waste management program in Puerto Rico. Raising awareness of water protection measures, enforcing land-use regulations, studies and analysis. Develop capacity and collaboration among practitioners to increase awareness and compliance on septic systems.
TA/Training	Align with the current EDA initiative to strengthen overall grant-writing and administrative capacity—beyond either EDA or CDBG-MIT resources. Increase general grant-writing and administration capacity to leverage state, federal, and private funding that can support lifeline activities.
Lifeline Support and Adaptation Training Programs	Support implementation of lifelines through workforce training programs in direct support of one (1) or more of the seven (7) community lifelines. Train and certify Puerto Ricans in environmental skills trades needed to recover critical services after disasters, such as flood management, disaster debris removal, mold, lead and asbestos remediation, community water systems operators, and municipal sanitation workers. Build capacity through training and development of a community health worker program.

ELIGIBLE ACTIVITIES:

- Section 105(a)(3) - Code Enforcement
- Section 105(a)(8) - Provision of Public Services
- Section 105(a)(12) – Planning and Capacity Building
- Section 105(a)(14) – Activities Carried Out through Nonprofit Development Organizations
- Section 105(a)(21) – Assistance to Institutions of Higher Education

INELIGIBLE ACTIVITIES:

- Supplanting of funds for inherently governmental staff duties that are not temporary in nature to address mitigation planning surge capacity needs.

METHOD OF DISTRIBUTION: Direct Distribution and Sub-Recipient Distribution Models. The Planning and Capacity Building Program will be administered by PRDOH or a Government of Puerto Rico entity by Subrecipient Agreements, Interagency Agreements, or Memorandums of Understanding which may be utilized to execute defined portions of this Program.

NATIONAL OBJECTIVE: N/A

ELIGIBLE ENTITIES:

- Units of general local government/ municipalities (including departments and divisions)
- Government of Puerto Rico Agencies, Authorities, Trusts and Boards
- Community-Based Development Organizations and private non-profits
- Non-governmental organization (501(c)(3)) or Not for Profit Entities

MIN AWARD: $300,000

MAX AWARD: $1,000,000. No exceptions to the max award will be considered.

ALIGNMENT WITH CDBG-DR PROGRAMS:

- The Planning and Capacity Building Program will build on information and progress made through the CDBG-DR planning programs including the MRP Program, WCRP Program, and the GeoFrame Program. It will also utilize, as it becomes available, information collected under the CDBG-MIT RAD Collection Program.

ALIGNMENT WITH HUD POLICY OBJECTIVES:

- **Build the capacity of States and local governments** to comprehensively analyze disaster risks and to update hazard mitigation plans through the use of data and meaningful community engagement.

- **Support the adoption of policies** that reflect local[237] and regional priorities that will have long-lasting effects on community risk reduction, to include the risk reduction to community lifelines such as Safety and Security, Communications, Food, Water, Sheltering, Transportation, Health and Medical, Hazardous Material (management) and Energy (Power & Fuel); and future disaster costs (e.g., adoption of forward-looking land use plans that integrate the hazard mitigation plan, latest edition of the published disaster-resistant building codes and standards, vertical flood elevation protection, and policies that encourage hazard insurance for private and public facilities).
- Maximize the impact of available funds by **encouraging leverage, public-private partnerships, and coordination** with other Federal programs.

ALIGNMENT WITH ECONOMIC RECOVERY PLAN ALIGNMENT:

- **CPCB 4** Resilience Building in Collaboration with High-Risk Communities
- **MUN 4** Build the Capacity of Municipalities to Apply for, Secure, and Manage Grants
- **MUN 7** Create and Implement a Model of Regional Service Delivery and Planning
- **HSS 22** Move to a More Regionally Integrated Approach to Emergency Planning, Exercising, Response, and Recovery
- **HSS 3** Implement Integrated Waste Management Program and Expand Programs to Increase Recycling Rates
- **NCR 11** Establish a Long-Term, Sustainable, Integrated Solid Waste Management Program

ALIGNMENT WITH OTHER FEDERAL PROGRAMS:

- EDA grant programs that support planning and development grants to established EDDs.
- FEMA Hazard Mitigation and Pre-Disaster planning programs. HUD stipulates at 84 FR 45838, 45849 that planning programs may also use these funds for planning activities, including but not limited to, regional mitigation planning; the integration of mitigation plans with other planning initiatives; regional or multi-jurisdictional planning activities that are mitigative in nature; activities related to FEMA's Pre-Disaster Mitigation (PDM, to be renamed Building Resilient and Infrastructure Communities (BRIC) as part of the implementation of section 1234 of the Disaster Recovery Reform Act of 2018, which amended section 203 of the Stafford Act (42 U.S.C. § 5133)) and Flood Mitigation Assistance (FMA); modernizing building codes and regional land-use plans; and upgrading mapping, data, and other capabilities to better understand evolving disaster risks.

[237] PRDOH interprets the word local to mean municipal in this context.

INFRASTRUCTURE MITIGATION PROGRAM

RISK-BASED NEED: The Infrastructure Mitigation Program serves to address mitigation needs by improving the built environment in order to mitigate hazardous threats. Infrastructure mitigation projects must mitigate risk to infrastructure assets within one or more of the seven (7) community lifelines. Due to the multi-hazard threats that Puerto Rican communities face, the Island is in need of transformative mitigation projects that not only address facility hardening or retrofits, but more importantly address the reduction of multiple threats to lifeline infrastructure and citizens by mitigating the localized conditions that cause wide-scale destruction and lead to disaster events. Such transformative projects are therefore incentivized in project selection criteria, explained in the Project Evaluation section below. This program design represents a practical approach to maximizing limited mitigation dollars to serve the greatest need possible.

The PRDOH Risk Assessment revealed the top ten (10) risks[238] from an Island-wide perspective as the following:

1	**Hurricane Wind**
2	**Flood 100**
3	**Earthquake**
4	**Landslide**
5	**Liquefaction**
6	**Drought**
7	**Severe Storm**
8	**Sea Level Rise (10ft)**
9	**Wildfire**
10	**Human-Caused Hazard**

Municipal, neighborhood, community, and regional threats differ greatly when local geography and geographic susceptibility to hazards is considered. It is for this reason that the Infrastructure Mitigation Program promotes data-informed decision making for all eligible applicant entities by launching the publicly transparent Risk Assessment and Regional Lifeline Assessment tools.

Because it is understood that the risk at any individual location may diverge from the top Island-wide risk assessment results provided by the PRDOH analysis, the Risk Assessment

[238] The full results of the Risk Assessment with a complete ranking of all eighteen (18) hazards can be found in the Risk Assessment section of this draft.

Tool is not intended to serve as a doctrine to restrict projects, but to enable decision makers.[239]

Risk Assessment Tool	Regional Lifelines Assessment Tool
	
The **Risk Assessment Tool** is a GIS dashboard that helps applicants to identify areas of risk and provide insight in the development of projects that mitigate that risk. It should be used as a tool to inform decision-makers and communities when identifying high risk in their area or region, and support them to develop solutions to mitigate those risks.	The **Regional Lifelines Assessment Tool** is a GIS dashboard that provides program applicants with aggregated data from federal and state entities to identify the geolocation of critical lifeline infrastructure. This tool also displays the HUD LMISD summary data population count by municipality and region.[240]

The results of the Risk Assessment should inform the public sector, emergency response, private sector service providers, and communities of an initial ranking of risk to aid in the development of mitigative solutions. The purpose of this Program is to empower applicant entities to identify risks, and develop solutions to mitigate risk, through innovative, eco-conscious, and self-sustaining solutions that support stability in lifelines to create a resilient infrastructure system for Puerto Rico.

PROGRAM DESCRIPTION: PRDOH will administer one (1) Mitigation Infrastructure Program intended to fund projects within the full range of eligible public facilities improvement activities so long as the project mitigates identified risk(s). Projects must demonstrate risk mitigation properties that benefit the population under the urgent need or LMI national objective, and LMI beneficiaries must be prioritized. The greater number of hazards mitigated by one project, the better. Smaller-scale projects that mitigate the most risk for specific neighborhoods, municipalities, or regions shall be considered if they are an established priority project and supported by a sound feasibility analysis and justification. The most competitive projects, however, will be those that leverage regional solutions and partnerships, provide a greater risk reduction benefit to the critical lifelines, and benefit more citizens.

Due to the varying and localized need for mitigation against a number of hazardous threats, PRDOH does not want to limit projects based on the top risks at the Island-wide

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[239] Planning tools shown here can always be found as link on the CDBG-MIT website in English and Spanish at https://cdbg-dr.pr.gov/en/cdbg-mit/ and https://cdbg-dr.pr.gov/cdbg-mit/.
[240] HUD LMISD data is the required beneficiary data set for qualifying projects according to area benefit.

level, nor by an assumption of need in a generalized way. The ultimate goal of this Program is to strategically identify areas of risk and mitigate the most risk for the greatest amount of people in a cost-effective manner. This is best accomplished through planning, design, and innovation realized through the implementation of public facilities improvement eligible under this Program. Projects eligible for funding are intended to serve the needs of the people by allowing for scaled investments that make critical mitigation dollars accessible to all communities on the Island: municipal, regional, or Island-wide.

PROJECT EVALUATION CRITERIA: Evaluation of project eligibility and competitive qualities will include criteria focused on mitigation of threats identified within the jurisdiction(s) where the project provides benefit. By utilizing the results of the risk assessment, each project will be given a Risk Mitigation Score. This score is based on potential mitigated risk, or a Mitigation Index Ratio **(MIT Index)**, project beneficiaries, and project cost.

By basing project selection on the Risk Mitigation Score, projects that reduce risk to the greatest number of people at the lowest cost will be prioritized. Furthermore, because critical lifelines were intrinsic to the calculation of risk as part of the risk assessment, and because of the interdependent nature of critical lifelines, projects that mitigate risk to one (1) or more of the critical lifelines will receive a higher Risk Mitigation Score than those that mitigate risk to only secondary lifelines. Applicants can predict their Risk Mitigation Score by utilizing the Risk Assessment Tool.

Applicants should refer to the Risk-Based Needs Assessment section of the Action Plan for advisory activities to serve mitigation and resilience needs. At a high level, mitigation project activities should support:

- Strengthening of resilience corridors within the **Transportation** lifeline
- Building improvements should incorporate alternative **energy** technology and equipment, where appropriate, into facilities improved by mitigation dollars.[241] Equipment must be permanent in nature and be considered an integral part of the facility.
- Improving the resilience of publicly owned **Communications** lifeline infrastructure, especially communications assets that are needed to facilitate critical response activities.[242] Building improvements should consider incorporating redundant **communications** technology and equipment, where appropriate, into facilities improved by mitigation dollars. Equipment must be permanent in nature and be considered an integral part of the facility.
- Strengthening, modernizing, replacing, or building **water/wastewater** infrastructure to withstand high-risk hazardous activity that poses a threat to asset stability in a disaster event.

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[241] Projects for alternative energy infrastructure solutions that reduce Puerto Rico's fossil-fuel dependence should apply to the Community Energy and Water Resilience Incentives Program.

[242] Projects for improvement of privately-owned communications infrastructure should apply to the Economic Development Portfolio for Growth – Mitigation program.

- Improving, expanding, or constructing **healthcare and medical** facilities to fortify and innovate buildings and permanent equipment.
- Improving or fortifying **solid waste** infrastructure within the hazardous waste lifeline to reduce the risk of health threats associated with landfills overfill and instances of clandestine dump sites that only increase with every hazardous event.
- Improving or fortifying **Safety and Security** lifeline infrastructure supports law enforcement/security, fire service, search and rescue, community safety, etc. upon HUD granting a waiver to allow for CDBG-MIT funds to be used for buildings for the general conduct of government.

In addition to the mitigative properties described above, projects will be evaluated for additional criteria concerning compliance, innovation, and eco-conscious measures including but not limited to:

- Percentage of LMI benefit. Projects that serve fifty-one percent (51%) or more LMI households within the area of benefit will be prioritized.
- Whether or not the project provides regional benefit to multiple jurisdictions.
- If the project capitalizes on public and private partnerships for which the public match (only) is requested through this Program.
- If the project leverages CDBG-MIT funding with other federal, Government of Puerto Rico, and/or local funding sources.
- The feasibility of the project's long-term operations and maintenance plan that addresses the operations and maintenance costs of the infrastructure improved. All applicants are required to submit a long-term operations and maintenance plan and must identify reasonable milestones for any plan that will be reliant on proposed changes to existing taxation policies or tax collection practices.
- Whether the natural infrastructure is preserved, or other eco-conscious measures are included in project design to minimize the unintended consequences of grey infrastructure and other development. Applicants are encouraged to incorporate innovative nature-based solutions and natural or green infrastructure solutions during project development that reduce the negative impacts on the surrounding human and natural environment. Natural or green infrastructure is defined at 84 FR 45838, 45848 as the integration of natural processes or systems (such as wetlands or land barriers) or engineered systems that mimic natural systems and processes into investments in resilient infrastructure, including, for example, using permeable pavements and amended soils to improve infiltration and pollutant removal.
- Whether or not local code enforcement supports modern and/or resilient building codes and mitigation of hazard risk, including possible sea level rise, high winds, storm surge, and flooding.
- Whether the project considered innovative design solutions that:
    - Improve the quality of life
    - Stimulate sustainable grown and development
    - Enhance public health and safety
    - Minimize noise and vibration

- o Minimize light pollution
- o Improve community mobility and access
- o Encourage alternative modes of transportation
- o Improve site accessibility and safety
- o Preserve Historic and Cultural resources
- o Preserve or improve views and local character
- o Encourage stakeholder involvement
- o Address conflicting regulations and policies
- o Extend the project facility lifespan
- o Reduce energy consumption
- o Make use of recycled materials
- o Make use of local or regional materials
- o Divert waste from landfills
- o Reduce waste during construction

Projects that are $25 million or more in total project value shall also be evaluated for feasibility in order to ensure selected projects deliver the benefit of mitigation from risk to the greatest number of Puerto Ricans. This will require that all projects sufficiently provide evidence of project feasibility to allow PRDOH to make a determination of one of the following:

- A feasible project will demonstrate the ability to complete all necessary activities for the amount requested in the application. The applicant will be required to demonstrate that the project estimate includes the capacity to complete acquisition, permitting, design, environmental clearance, and all other activities necessary to complete construction of the mitigation project.
- If a project, based on the evaluation criteria, appears to be a good mitigation project, but does not adequately demonstrate the capacity to complete all necessary activities, at PRDOH's discretion, the applicant may be allocated funding contingent upon the completion of a feasibility analysis. If after completion of the feasibility analysis, the project demonstrates the ability to achieve project completion, PRDOH will allocate additional funding for design, environmental, and other activities required prior to construction. Prior to construction, PRDOH will make a final decision to fund all projects.

Final scoring and evaluation criteria will be released in the Program Guidelines.

PROJECT EXAMPLES: As a means to illustrate for public benefit, the risk and beneficiary considerations that should be taken into account when developing or evaluating the mitigative properties of a project, PRDOH provides two (2) scenarios shown in the pages that follow. For these scenarios, the following terms should be understood:

- Area of Benefit (**AOB**) - represents the total beneficiaries or persons receiving a mitigation benefit from the project. An AOB could be the service area of a wastewater treatment plant, neighborhoods served by an elevated roadway, or a residential neighborhood affected by community level flood mitigation.

The geographic area represented by the AOB is then used to determine the Risk Benefit Area.

- Risk Benefit Area (**RBA**) – is the aggregate of the hex grids found in the Risk Assessment Tool that reside within or connect to the AOB. If a hex-grid from the Risk Assessment is within the AOB it is part of the RBA. Furthermore, if a hex-grid is partially within or touching the AOB, it is also included as part of the RBA. Each hex-grid is one-half mile (0.5 mile) square. Therefore, the RBA is an area in square mile(s).
- Risk Score – each hex-grid has a risk score for each of the eighteen (18) hazards. Only the risk or risks mitigated should be considered when calculating a project Risk Score. This score can be added up based on the AOB to determine a total risk score for the project. The risk score is then used to determine the MIT Index Score and subsequently the Risk Mitigation score.
- MIT Index Score - the total Risk Score, determined by adding each hex-grid risk score together, divided by the square miles of the RBA is used to determine the MIT Index. The MIT Index represents the total potential risk mitigated by a project per area. The MIT Index Score is then used to determine the Risk Mitigation Score through consideration of beneficiaries, determined by the AOB, and Project Cost.
- Project Cost – is the total project cost, including all funding sources, necessary to complete construction or implementation of the CDBG-MIT project.
- Risk Mitigation Score – determined by multiplying the MIT Index by the AOB, or beneficiaries, and then dividing that result by the Project Cost. The resulting number is then multiplied by 100.

In Scenario One (S1) and Scenario Two (S2), the RBA is determined by identifying the total number hex-grids in the RBA and multiplying that total by the area of each hex-grid, half a mile (0.5 mile). The Risk score for each hex-grid is then added together and then divided by the RBA to determine the MIT Index. Finally, the MIT Index is multiplied by the total beneficiaries in the AOB, divided by the Project Cost and multiplied by 100. This yields the Risk Mitigation Score.

Scenario One (S1): Illustrates the calculation of a Risk Mitigation Score for a wetland restoration project that benefits a residential neighborhood by reducing the flood risk downstream through restoration of a natural environment resource.

First, the AOB is determined to identify total beneficiaries or persons receiving a mitigation benefit from the project. In this case, the population of neighborhood receiving the flood mitigation benefit from the wetland restoration project upstream is 10,000. The figure below illustrates the determination of the AOB for the S1 wetland restoration project.

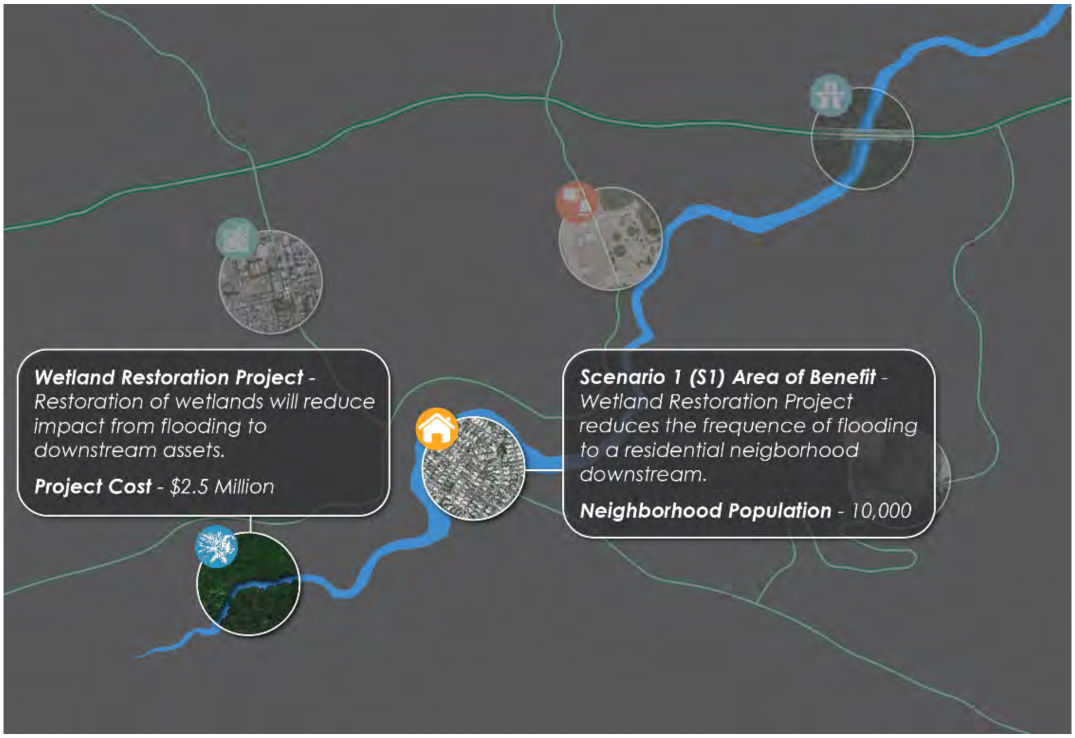

Figure 81. Scenario 1 Determination of Area of Benefit

Next, the RBA is determined. The square miles for each half mile (0.5 mile) hex-grid wholly or partially within or touching the AOB are added up for the total square miles of the RBA. The figure below illustrated the determination of RBA.

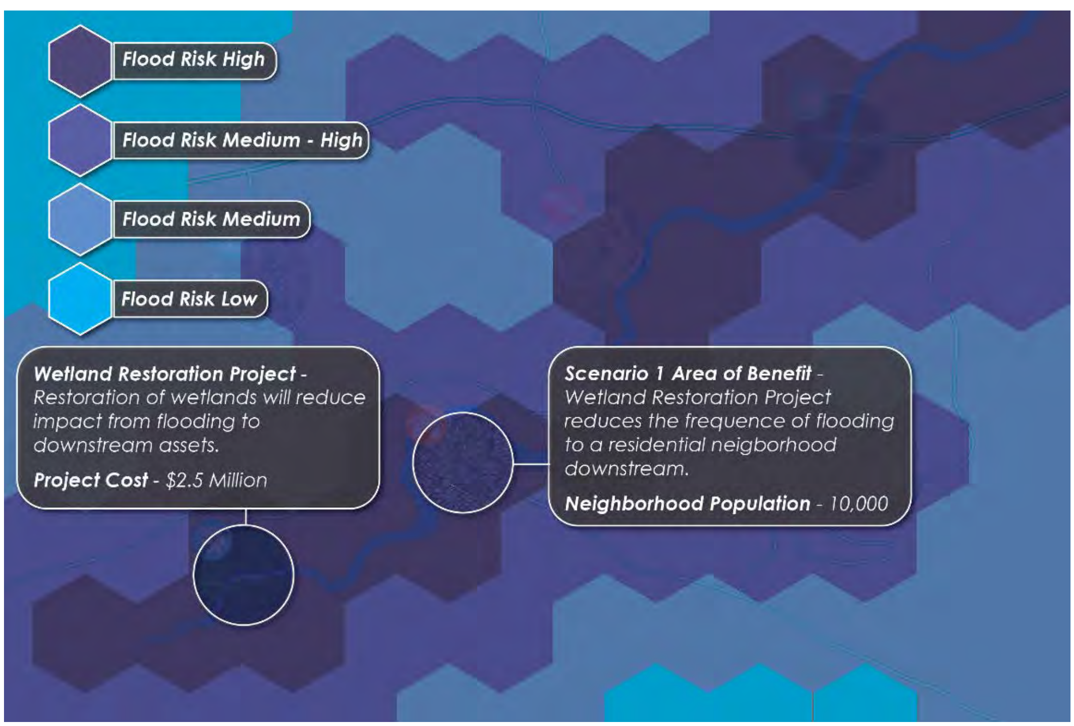

Figure 82. Scenario 1 Risk Benefit Area Determination

The Risk Score is then calculated by adding the flood score for each half mile (0.5 mile) hex-grid wholly or partially within, or touching, the AOB. The aggregate total of the risks for each hex-grid is then added together and divided by the square miles of the RBA to determine the MIT Index.

Finally, the MIT Index is multiplied by the total beneficiaries in the AOB, divided by the Project Cost and multiplied by 100. This yields the Risk Mitigation Score. The figure below illustrates the calculation necessary to determine the Risk Mitigation Score.

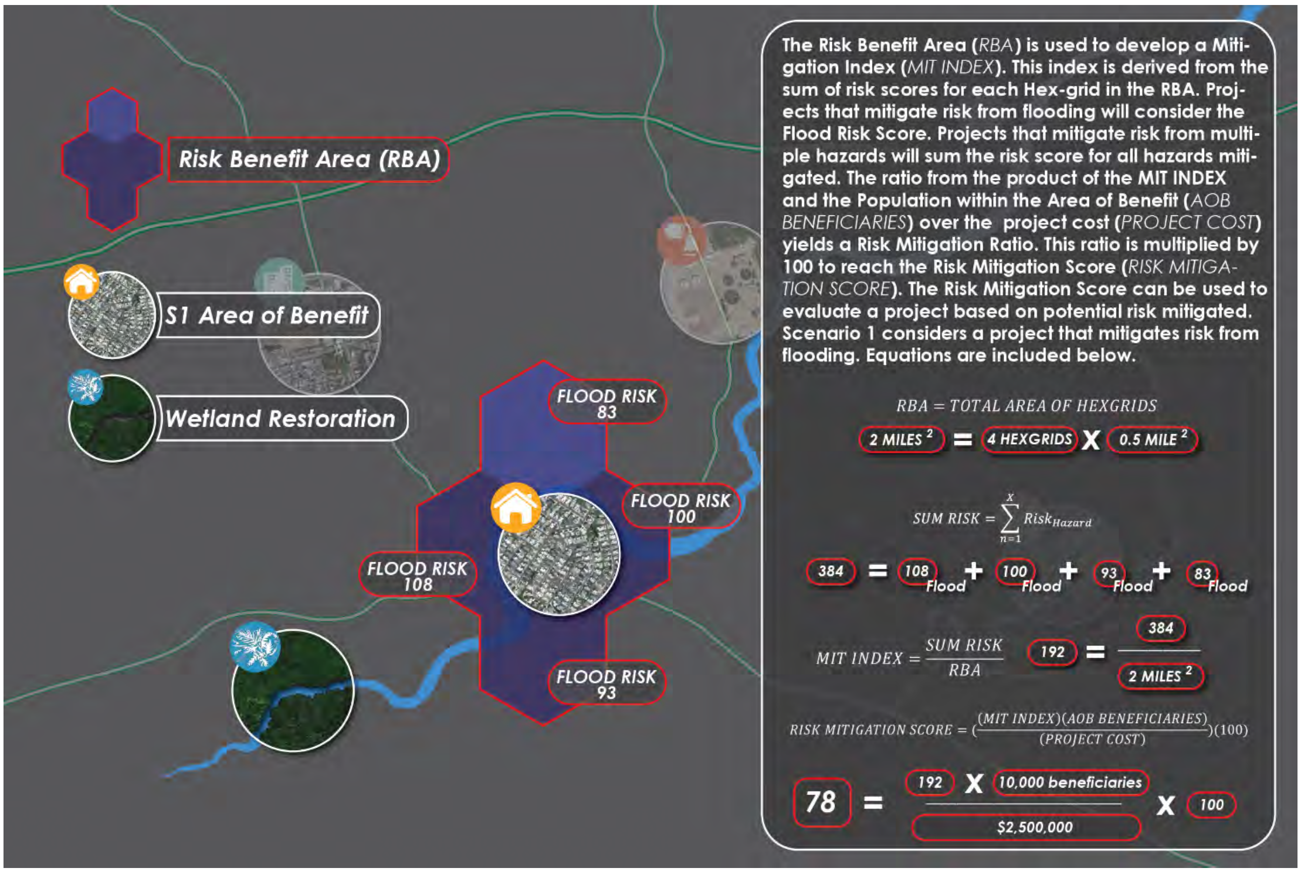

Figure 83. Scenario 1 Example Calculation

Scenario Two (S2): Illustrates the evaluation criteria for a wetland restoration project that benefits a residential neighborhood as well as critical Infrastructure facilities downstream of the wetland restoration project. Mitigation of risk to critical lifeline infrastructure provides a significant enhancement to overall risk mitigation and, therefore, increases the project's Risk Mitigation Score.

Just as we saw in the S1 example, for S2 the AOB is determined to identify total beneficiaries or persons receiving a mitigation benefit from the project. In this case, in addition to wetland restoration reducing the flood risk to the residential neighborhood, the project also reduces flood risk for nearby critical lifeline infrastructure facilities. In S2 this includes a downstream wastewater treatment plant and a downstream roadway bridge, and neighboring residential areas served by this critical lifeline infrastructure.

The figure below illustrates the determination of the AOB for the S2 wetland restoration project.

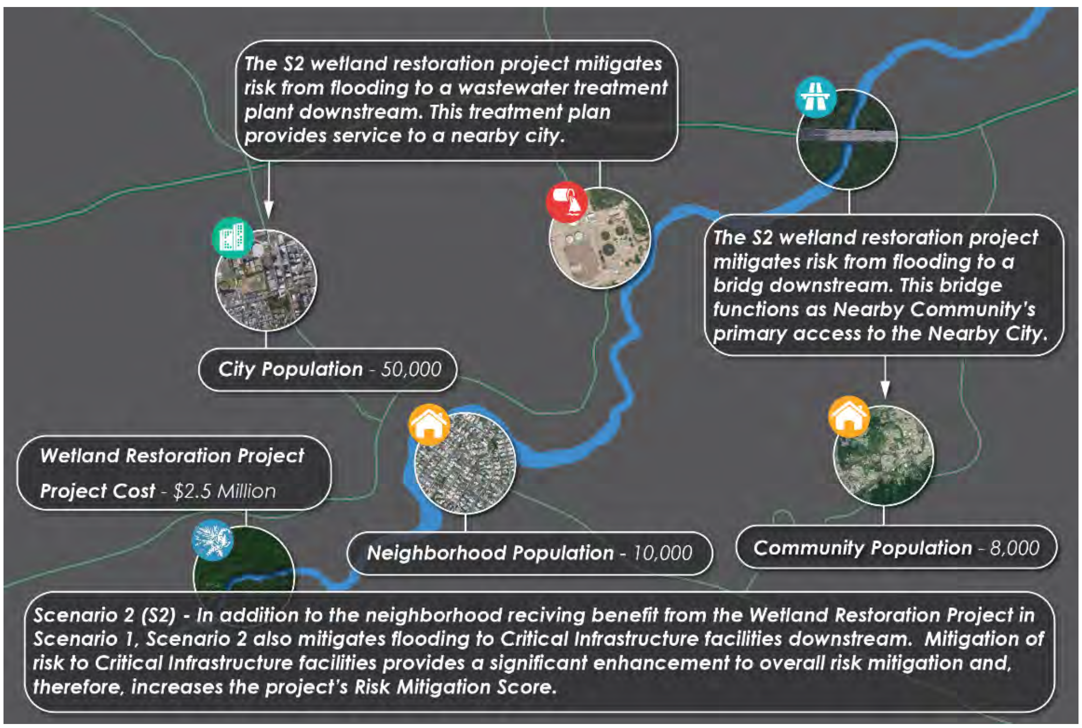

Figure 84. Scenario 2 Area of Benefit Determination

The RBA is determined with the same method used in S1 but considers a much broader square mile area. The square miles for each half mile (0.5 mile) hex-grid wholly or partially within or touching the AOB are added up for the total square miles of the RBA. The figure below illustrates the determination of the RBA.

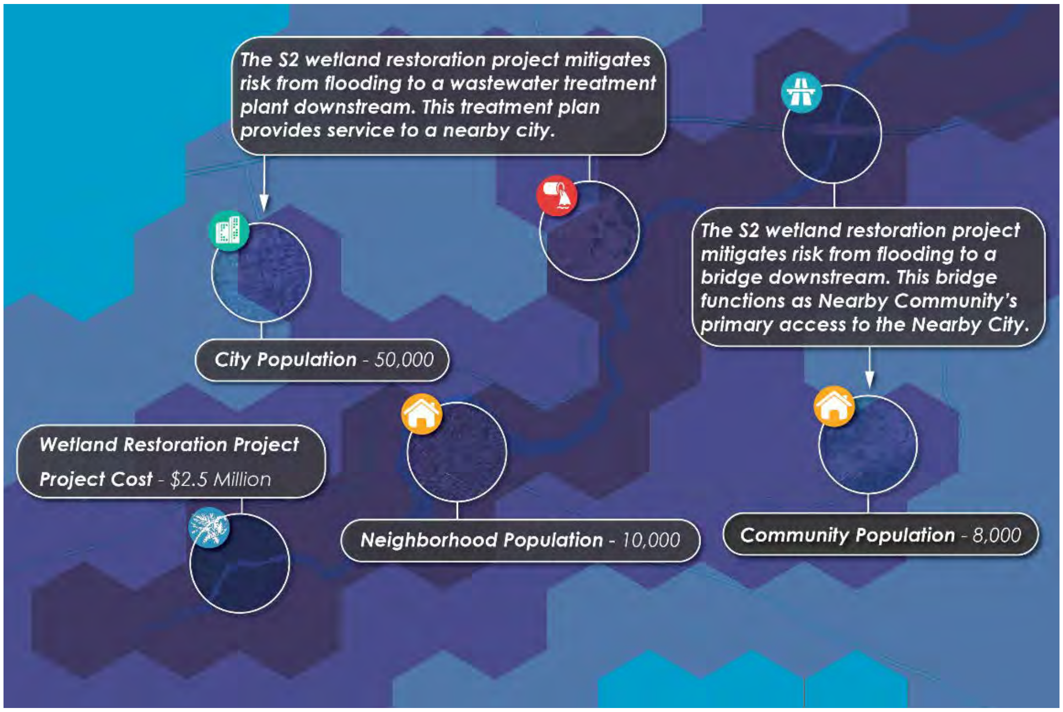

Figure 85. Scenario 2 Risk Benefit Area Determination

The Risk Mitigation Score is determined for S2 by the same method as Scenario 1; however, by providing risk mitigation benefit to critical infrastructure lifelines, there is an increase in the MIT Index, total beneficiaries, and Risk Mitigation Score.

The Risk Score is calculated by adding the flood score for each half mile (0.5 mile) hex-grid wholly or partially within or touching the AOB. The aggregate total of the risks for each hex-grid is then added together and divided by the square miles of the RBA to determine the MIT Index.

Finally, the MIT Index is multiplied by the total beneficiaries in the AOB, divided by the Project Cost and multiplied by 100. This yields the Risk Mitigation Score. The figure on the following page illustrates the calculation necessary to determine the Risk Mitigation Score.

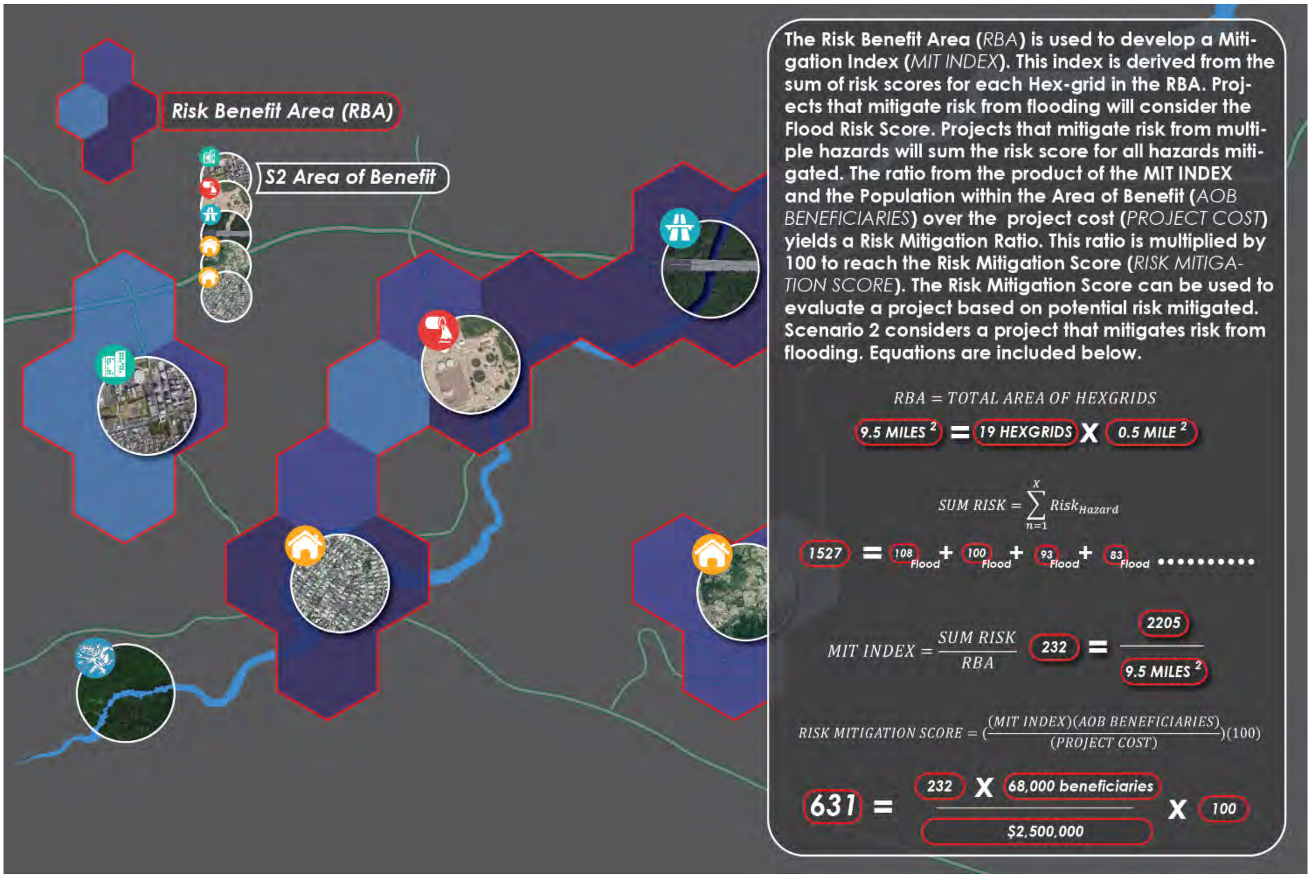

Figure 86. Scenario 2 Example Calculation

PROGRAM PHASING: The release of program funds shall be administered in phases over the twelve (12) year grant lifecycle on a schedule to be determined and published in the Program Guidelines. Priority will be given in the first phase to projects that, prior to construction, will have completed an extensive analysis of existing conditions, repetitive loss, past and future disasters, existing data, studies, and relevant federal, state, and local publications. Project design must show a significant improvement to existing conditions, and to the greatest extent feasible, mitigate risk to the population, public and private properties, infrastructure, the economy, economic assets, and/or natural resources of the Government of Puerto Rico.

BENEFIT COST ANALYSIS FOR COVERED PROJECTS. For Covered Projects, defined as $50 million dollars or more in total project cost with $25 million dollars or more in match funds from CDBG-MIT, CDBG-DR or CDBG, the project benefits must outweigh the costs. The preferred method for demonstrating this benefit is through the utilization of FEMA's BCA model and the analysis must result in a benefit-to-cost ratio greater than one point zero (1.0). HUD also allows for alternative methods such as[243]:

- A non-FEMA BCA methodology may be used when:

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[243] United States, Department of Housing and Urban Development, "Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees." 84 FR 45838. (August 30, 2019)

    - A BCA has already been completed or is in progress pursuant to BCA guidelines issued by other Federal agencies such as the USACE or the DOT;
    - The alternative BCA method addresses a non-correctable flaw in the FEMA-approved BCA methodology; or
    - The BCA method proposes a new approach that is unavailable using the FEMA BCA Toolkit.
- In order for HUD to accept any BCA completed or in progress pursuant to another federal agency's requirements, that BCA must account for
    - economic development,
    - community development and other social/community benefits, or
    - costs and the CDBG–MIT project must be substantially the same as the project analyzed in the other agency's BCA.
- Alternatively, for a Covered Project that serves LMI persons or other persons who are less able to mitigate risks or respond to and recover from disasters, the grantee may demonstrate that benefits outweigh costs using a qualitative description. The grantee completes a BCA as described above, and provides HUD with a benefit-to-cost ratio (which may be less than one), and a qualitative description of benefits that cannot be quantified but sufficiently demonstrate unique and concrete benefits of the Covered Project for LMI persons or other persons who are less able to mitigate risks, or respond to and recover from disasters. This qualitative description may include a description of how the Covered Project will provide benefits such as enhancing a community's economic development potential, improving public health and or expanding recreational opportunities.

BENEFIT COST ANALYSIS FOR NON-COVERED PROJECTS: All projects that do not trigger the Covered Project requirements will undergo a Risk-Benefit Analysis (**RBA**), a modified BCA evaluation process based on a project's MIT Index Score, the Area of Benefit (**AOB**) and the total project cost.

Equation 9: Risk-Benefit Analysis

$$RBA = \frac{(MIT\ INDEX)(AOB\ BENEFICIARIES)}{(PROJECT\ COST)}$$

A project's RBA score is then evaluated and compared to the project pool for funding selection.

HGMP MATCH SET ASIDE: This Program includes a one ($1) billion dollars set-aside for HMGP match to provide the required twenty-five percent (25%) non-federal match funding for FEMA HMGP projects through a Global Match Program. Projects funded by FEMA HMGP must comply with HMGP resilience standards and meet the mitigation standards of this Program according to the project evaluation criteria. By working with COR3 to execute dually funded resilience projects, PRDOH will advance long-term resilience to hazard risk identified in the Risk Assessment.

HEALTHCARE STRENGTHENING SET ASIDE: This Program includes a one ($1) billion dollar set-aside to strengthen healthcare facilities for the benefit of medically underserved Puerto

Ricans, and to minimize, through accessible healthcare, the fatalities likely from a disaster event. This can include improvements, expansions, and construction of new facilities to fortify and innovate buildings and permanent equipment. Improved and new facilities should demonstrably increase the capacity of Puerto Rico's healthcare system to mitigate the impacts of future disasters, both natural and human-caused, such as the COVID-19 pandemic. Building architecture for new construction must incorporate disaster-resistant building elements and self-sustaining power, water, and data communication features.

Such facilities should prove resistant to disaster-induced threats, thereby increasing the number of patients that can be sheltered and served in a disaster event. New resilient hospitals and clinics must be constructed to the most recent IBC 2018 standards and strategically located to reduce vulnerability to flooding and earthquakes. New facilities will be required to meet LEED or other appropriate green building standards. Building design should consider the integration of information technology and building architecture to support sustainable power and data communication. New construction must include the installation of tele-health technology.

Projects at or above $50 million dollars could exceed the threshold established by HUD, thereby requiring a full BCA in order for the projects to qualify for funding.

GREEN BUILDING STANDARD FOR ALL NEW CONSTRUCTION: Green Building Standard is required for all new construction funded under this Program, which means that PRDOH will require that all applicable construction meet an industry-recognized standard that has achieved certification under at least one of the following programs: (i) ENERGY STAR (Certified Homes or Multifamily High-Rise), (ii) Enterprise Green Communities, (iii) LEED (New Construction, Homes, Midrise, Existing Buildings Operations and Maintenance, or Neighborhood Development), (iv) ICC–700 National Green Building Standard, (v) EPA Indoor AirPlus (ENERGY STAR a prerequisite), (vi) the "Permiso Verde," or (vii) any other equivalent comprehensive green building program acceptable to HUD.

ELIGIBLE ACTIVITIES:

- Section 105(a)(1) – Acquisition of Real Property
- Section 105(a)(2) – Public Facilities and Improvements
- Section 105(a)(4) – Clearance, Rehabilitation, Reconstruction, and Construction of Buildings
- Section 105(a)(7) – Disposition of Real Property
- Section 105(a)(8) – Public Services
- Section 105(a)(9) – Payment of Non-Federal Share
- Section 105(a)(11) – Relocation
- Section 105(a)(12) – Planning
- Section 105(a)(13) – Payment of reasonable administrative costs
- Section 105(a)(14) – Activities Carried Out through Non-profit Development Organizations

- Section 105(a)(15) – Assistance to Eligible Entities for Neighborhood Revitalization, Community Economic Development, and Energy Conservation
- Section 105(a)(16) – Energy Use Strategies Related to Development Goals (resiliency)
- Section 105(a)(21) – Assistance to Institutions of Higher Education

INELIGIBLE ACTIVITIES:

- Projects that do not mitigate risk are ineligible.
- Projects that improve the power grid are strictly prohibited at this time. This prohibition shall be revisited upon the release of the almost $2 billion in CDBG-DR funds for power grid improvements.
- Projects may not enlarge a dam or levee beyond the original footprint of the structure that existed prior.
- The following activities are ineligible, pending HUD review and approval of waiver requests:
    - Assistance for building used for the general government conduct
    - Assistance to privately-owned utilities
    - Operations and maintenance costs cannot be funded with CDBG-MIT
    - Projects that address the national objective to address conditions of slum and blight are not eligible

METHOD OF DISTRIBUTION: Direct Distribution Model

NATIONAL OBJECTIVE: UNM; LMI. LMI prioritized up to fifty percent (50%). Projects qualifying under the UNM national objective will be required to submit as part of the application documentation showing how the proposed project will mitigate loss of life or impacts to properties in the project Area of Benefit (AOB).

ELIGIBLE ENTITIES:

- Units of general local government/ municipalities (including departments and divisions)
- Government of Puerto Rico Agencies, Authorities, Trusts and Boards
- Community-Based Development Organizations and private non-profits
- Non-governmental organization (501©(3)) or other non-profit entities

INELIGIBLE ENTITIES

- For-Profit Businesses are not eligible to apply

Non-government entities must demonstrate the support of the local municipality (ies) in which the project area and persons of benefit reside, either through formalized consortia or with executed memoranda of agreement (MOA). All applicants will be required to submit an operations and maintenance plan in order to qualify.

MIN AWARD: Based on cost reasonableness analysis.[244]

MAX AWARD: $100,000,000. Exceptions to the max award shall be considered by the PRDOH Special Case Panel on a case-by-case basis.

ALIGNMENT WITH CDBG-DR PROGRAMS:

- Flood and landslide mitigation projects that reduce risk to housing communities shall be directly tied together as part of the Housing Mitigation strategy as determined by the PRDOH Planning Group in collaboration with **CDBG-DR Home Repair, Reconstruction, or Relocation (R3) Program** and Flood Mitigation Housing Program applicants under CDBG-MIT. The Citizen Advisory Committee.[245] and eligible R3 applicants will be engaged through a participative planning process to identify these projects and discuss potential options to minimize the displacement of housing applicants under both CDBG-DR and CDBG-MIT.

ALIGNMENT WITH HUD POLICY OBJECTIVES:

- **Support data-informed investments** in high-impact projects that will reduce risks attributable to natural disasters, with particular focus on repetitive loss of property and critical infrastructure.
- Maximize the impact of available funds by **encouraging leverage, private-public partnerships, and coordination** with other Federal programs.

ALIGNMENT WITH ECONOMIC RECOVERY PLAN:

- **WTR 1** Resilient Repair or Replacement of the PRASA Drinking Water System
- **WTR 2** Improve the Operational Efficiency and Performance of PRASA Water and Wastewater Systems
- **WTR 3** Enhance the Efficiency and Resilience of PRASA Electricity Services
- **WTR 4** Enhance Ability to Transfer Potable Water Among PRASA Service Zones
- **WTR 5** Improve Treatment and Storage Capacity to Handle High Turbidity Events
- **WTR 6** Expand PRASA Services to Unconnected Areas. Connect and convert non-PRASA systems to PRASA drinking water systems and connect communities with septic tanks and publicly owned wastewater systems to PRASA sewage, where technically and financially practical. Where not technically feasible, please see the Sustainable Communities section.
- **WTR 10** Curtail Unauthorized Releases into Sanitary Sewers
- **WTR 11** Repair, Replace, and Improve PRASA Wastewater Treatment Plants and Sanitary Sewer Collection Systems
- **TXN 2** Harden Vulnerable Transportation Infrastructure
- **TXN 16** Repair Damage to Surface Transportation Network

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[244] Low cost projects that mitigate a high number of risks for a large number of beneficiaries shall not be excluded. Such projects could include technological solutions with wide-ranging benefits.
[245] The Citizen Advisory Committee is a citizen advisory committee that has been formed under the CDBG-DR program and will be utilized to address both CDBG-DR and CDBG-MIT public information and citizen participation efforts.

- **TXN 22** Increase Port Facility Resilience
- **NCR 9** Landfill Repair and Closure
- **NCR 13** Reduce Sediment Pollution and Risk from Landslides
- **NCR 14** Water Quality Improvements at the Watershed Scale
- **NCR 16** Wetlands Restoration
- **NCR 17** Reduce Coastal Erosion and Provide Disaster Protection Through Beaches and Dunes
- **WTR 18** Invest in Stormwater System Management
- **WTR 19** Reduce Urban Nuisance Flooding
- **WTR 20** Relocate or Redesign Assets in Flood Zones
- **NCR 8** Increase Landfill Capacity to Dispose of Hurricane-Related Waste and to Properly Manage Future Waste
- **PBD 9** Repair All Essential Public Buildings Damaged by Hurricanes Irma and Maria
- **PBD 10** Incentivize State-of-the-Art Building Design, Practices, and Technologies
- **WTR 19** Reduce Urban Nuisance Flooding
- **WTR 23** Evaluate, Repair, and Improve Flood Control Infrastructure
- **CIT 22** Use Federal Programs to Spur Deployment of Broadband Internet Island-Wide
- **HSS 1** Increase Use of Solar-Powered Generators and Solar Backup Power Sources
- **HSS 9** Increase Access to Tele-Health Options as Telecommunication Supports Become More Robust
  PBD 8 Mitigate Flood Risk for Critical Government Functions

HOUSING MITIGATION PROGRAM

RISK-BASED NEED: Flooding is one of the Island's top risks as outlined in the Risk Assessment, and is by far the most destructive hazard for Puerto Rico. Each year as tropical storms and hurricanes bring in bouts of flood-inducing rainfall, thousands of homes face the risk of flood and flood-induced landslides. These risks threaten single-family and multi-family housing indiscriminately. Assistance to public housing units that serve vulnerable communities is currently addressed through the HMGP match which includes fifty-nine (59) potential public and multi-family housing projects with mitigative properties.

This Program, addresses the need to reduce loss of life and property by offering relocation and elevation, where feasible, for single-family homeowners due to the oversubscription of applicants to the CDBG-DR R3 Program[246], and the consideration that assistance for multi-family housing projects is currently being addressed through CDBG-DR programs.[247] This program serves to minimize the risk of displacement and/or homelessness by providing vulnerable homeowners with an alternative option to living in a high-risk and in some cases unlivable area.

Many of the single-family homes in floodplain areas experience repetitive loss, but because of high costs and poorly documented property ownership for single-family properties, enrollment in the NFIP or other private insurance is low, and these losses are therefore not always captured in data sets nor are homeowners eligible for first-wave federal assistance programs. Less than four percent (4%) of households in Puerto Rico had flood insurance going into Hurricane María.[248]

After Hurricanes Irma and María, FEMA developed an Advisory 100-year Special Flood Hazard area based on inundation resulting from the Hurricane María event. The figure below shows the current FEMA 100-year Floodplain (left) and the FEMA Advisory 100-year Floodplain (right).

[246] The CDBG-DR Home Repair Reconstruction and Relocation (R3) Program - provides assistance to homeowners to repair damaged homes or rebuild substantially damaged homes in place in non-hazard areas.

[247] These CDBG-DR multi-family assistance programs are intended to serve vulnerable populations, homeless and at-risk of homelessness, and public housing developments.

[248] Wharton Risk Center Issue Brief March 2018, *Residential Flood Insurance in Puerto Rico.* Accessed at: https://riskcenter.wharton.upenn.edu/wp-content/uploads/2018/03/WRCib2018_Flood-Insurance-in-Puerto-Rico.pdf.

FEMA 100-year Floodplain	FEMA Advisory 100-year Floodplain

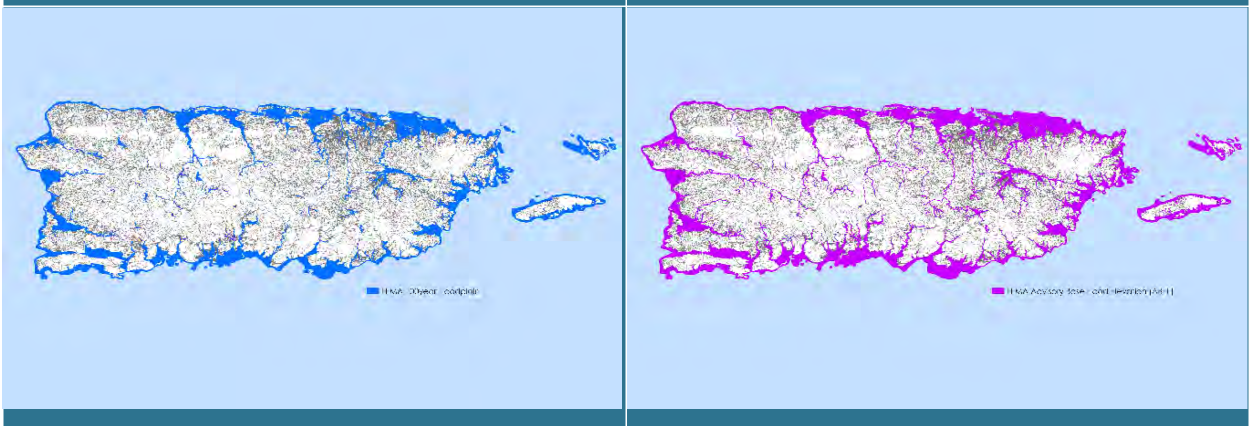

Figure 87. Side by side of FEMA 100-year Floodplain and FEMA Advisory 100-year Floodplain

Of the population in Puerto Rico, approximately sixteen percent (16%) the people reside within the FEMA 100-year Floodplain. That number increases to twenty-two percent (22%) of the population when compared to the FEMA Advisory 100-year Floodplain. Based on the average number of persons per-home in Puerto Rico, this represents in total an estimated 216,055 homes. The table below shows the estimated population, percentage, and estimated number of homes in the FEMA 100-year Floodplain and the FEMA Advisory 100-year Floodplain.

Estimated Population, Percentage and Estimated Number of Homes in the FEMA 100-year Floodplain and the FEMA Advisory 100-year Floodplain			
Evaluated Special Flood Hazard Area	Estimated Population	Percent of ACS Population	Estimated Number of Homes
FEMA 100-year Floodplain	579,028	16%	216,055
FEMA Advisory 100-year Floodplain	795,822	22%	296,949
*Estimated number of homes is based on 2018: ACS 1-Year Estimates; 2.68 persons per-home in Puerto Rico. 1,179,637 estimated homes in Puerto Rico;			

PROGRAM DESCRIPTION: The Housing Mitigation Program is available to households that reside in the FEMA Advisory 100-year Floodplain and shall include homeowner applicants currently in the CDBG-DR R3 program that are seeking alternative solutions to relocation.

The Housing Mitigation Program has been designed to prioritize flood mitigation solutions for homeowners interested in relocation or elevation as a means to reduce the risk of loss of life and property. Damage from flooding and other rain induced events is a top threat to Puerto Rican homes. Thus, this program offers individual flood-and-landslide-threatened homeowners with the option to investigate the feasibility of elevation of their home or opt in for voluntary relocation.

R3 Program participants interested in this program are being offered the chance to go *on hold* under CDBG-DR in favor of pursuing options through a participatory mitigation planning process that may allow them to reconstruct and elevate their home in place, contingent upon a feasibility analysis. This planning process shall be conducted in collaboration with the Citizen Advisory Committee in the role of the CDBG-MIT citizen advisory committee.

R3 applicants will be given the chance to decide if they would like to apply to the Housing Mitigation Program or accept the relocation award from the R3 Program. Should they choose the former, eligibility acceptance can be expected because eligibility requirements can be designed to be substantially similar to those for R3.

Additionally, where possible, PRDOH will identify, through regional planning efforts under the PRDOH Planning Group, opportunities for flood mitigation projects to reduce flood and landslide risk to homes otherwise seeking relocation as the only option to mitigate flood and landslide loss in the future.

AREA OF ELIGIBILITY: Single-family home structures located in the FEMA Advisory 100-year Floodplain are eligible to apply. Interactive public maps will be provided at the time of program launch to allow citizens to rapidly identify if their home is within the Advisory flood plain area.

ELEVATION: As required in 84 FR 45838, 45864, PRDOH will apply elevation standards for single family housing structures located in the Advisory 100-year (or one percent (1%) annual chance) floodplain to require that homes elevated, or reconstructed and elevated, raise the lowest floor (including the basement) to at least two (2) feet above the base flood elevation (**BFE**).

Homeowners applying for elevation must be aware that the option for elevation will be contingent upon a feasibility analysis to consider, at a minimum:

- Whether elevating a home in place leaves the homeowner vulnerable to limited evacuation routes in the event of a disaster, thereby not removing a homeowner from harm's way;
- Whether the cost of elevating a home is at or below thirty percent (30%) of the cost for a newly constructed home in place (not to exceed $55,500.00) or $55,500.00 for an original home that can be raised;
- Whether or not raising a home to the BFE plus two (2) feet is feasible when considering the potential for transferring flood risk to the surrounding neighborhood; and/or
- Whether the home parcel permits enough space for stair and/or rampway access.

The housing stock in Puerto Rico is generally more resilient to floods when compared to the construction of homes in many floodplain areas of the mainland US. Most Puerto Rican homes are poured concrete, slab-on-grade, with concrete roofs, which are sturdier and resistant to structural damage by floodwaters. Several feet of floodwater in a concrete house with no drywall, subfloor, or insulation will effect much less damage than the same height of floodwater in a wooden home with drywall and insulation.[249] This standard of construction, however, and the close proximity of Puerto Rican homes must be taken into consideration as these factors may complicate the potential for elevation options and could create safety concerns at the neighborhood level by adversely impacting flood patterns.

Homes determined eligible at the conclusion of the feasibility analysis will proceed forward with the eligibility process. Poured concrete, slab-on-grade homes will likely require reconstruction of the home to minimize cost and ensure safety of the home structure. Homes located in the floodway will not be eligible for elevation. If elevation is determined to be infeasible, the property owner will be provided an alternative option for relocation.

RELOCATION: At the time it is determined that a homeowner is eligible for relocation, the homeowner will be provided with housing counseling services where information on housing options will be made available and the homeowner will be given a change to make an informed decision regarding those options. Relocation allows for PRDOH acquisition of the damaged property, coupled with a housing voucher which allows the applicant to select a home outside of a high-risk area. Damaged properties acquired by PRDOH will be demolished and vacant lots will be maintained as green space. Replacement homes will be existing units. Units may also be bank-foreclosed properties, a market-listed unit, or a home in a condominium or co-op. Existing homes must be located in Puerto Rico and must meet Housing Quality Standards (**HQS**), and pass applicable environmental clearance and permit requirements before an applicant awardee may move in.

ALTERNATIVE PLANNING SOLUTIONS TO MINIMIZE DISPLACEMENT: The PRDOH MIT Planning Group will support community-level flood mitigation solutions by gathering site locations for each housing structure submitted to CDBG-DR and CDBG-MIT in order to track, and evaluate, where comprehensive flooding solutions might be possible within the pool of applicants. Additional watershed and feasibility studies submitted by municipalities, NGOs and advocacy groups will be considered in this evaluation. The PRDOH Planning Group will consider comprehensively how mitigation funding can support the integration of science and technology, as well as the support of the policy, in order to reduce or remove households from flood and flood-induced landslide risk.

QUALITY CONSTRUCTION AND GREEN BUILDING STANDARDS: PRDOH will implement construction methods that emphasize quality, durability, energy efficiency, sustainability, and mold resistance. All elevation-eligible homes that are reconstructed in place will be designed to incorporate principles of sustainability, including water and energy efficiency, resilience, and mitigation against the impact of future shocks and stressors.

[249] Wharton Risk Center Issue Brief March 2018, ***Residential Flood Insurance in Puerto Rico.*** Accessed at: https://riskcenter.wharton.upenn.edu/wp-content/uploads/2018/03/WRCib2018_Flood-Insurance-in-Puerto-Rico.pdf.

The Green Building Standard means that PRDOH will require that all applicable construction meets an industry-recognized standard that has achieved certification under at least one (1) of the following programs: (i) ENERGY STAR (Certified Homes or Multifamily High-Rise), (ii) Enterprise Green Communities, (iii) LEED (New Construction, Homes, Midrise, Existing Buildings Operations and Maintenance, or Neighborhood Development), (iv) ICC–700 National Green Building Standard, (v) EPA Indoor AirPlus (ENERGY STAR a prerequisite), (vi) the "Permiso Verde," or (vii) any other equivalent comprehensive green building program acceptable to HUD. PRDOH will identify which Green Building Standard will be used in the program policies and procedures, as per HUD requirements.

Where feasible, Puerto Rico will follow best practices such as those provided by the US Department of Energy's Guidelines for Home Energy Professionals. For all reconstructed structures, this may require installed appliances to meet ENERGY STAR certification standards at a minimum.

ELIGIBLE ACTIVITIES:

- Section 105(a)(1) – Acquisition of Real Property
- Section 105(a)(4) – Housing Construction, Acquisition, Green Building Standards
- Section 105(a)(7) – Disposition of Real Property
- Section 105(a)(15) – Assistance to Eligible Entities for to Neighborhood Revitalization, Community Economic Development and Energy Conservation

INELIGIBLE ACTIVITIES:

- Home rehabilitation activities in the absence of elevation are ineligible

METHOD OF DISTRIBUTION: Direct Distribution Model

NATIONAL OBJECTIVE: LMI only

ELIGIBLE APPLICANTS:

- Homeowners with clear ownership of an eligible single-family property located in a high-risk area
- Must qualify as LMI (below 80% Area Median Family Income (**AMFI**))
- Property must be the homeowner's primary residence
- Home must be located in the FEMA Advisory 100-year flood plane

MIN AWARD: Based on cost feasibility analysis

MAX AWARD: $185,000.00 for relocation; $265,500.00 for elevation (to include composite home price for new construction max of $185,000.00 + elevation costs up to $55,500.00 + demolition and debris removal up to $25,000.00)

Exceptions to the max award will be considered when necessary to comply with federal accessibility standards or to reasonably accommodate a person with disabilities.

ALIGNMENT WITH CDBG-DR PROGRAMS:

- Flood and landslide mitigation projects that reduce risk to housing communities shall be directly tied together as part of the Housing Mitigation strategy as determined by the PRDOH Planning Group in collaboration with **CDBG-DR R3 Program** and Flood Mitigation Housing Program applicants under CDBG-MIT. The Citizen Advisory Committee[250] and eligible R3 applicants will be engaged through a participative planning process to identify these projects and discuss potential options to minimize displacement of housing applicants under both CDBG-DR and CDBG-MIT.

ALIGNMENT WITH HUD POLICY OBJECTIVES:

- **Support data-informed investments** in high-impact projects that will reduce risks attributable to natural disasters, with a particular focus on the repetitive loss of property and critical infrastructure.
- **Support the adoption of policies** that reflect local[251] and regional priorities that will have long-lasting effects on community risk reduction, to include the risk reduction to community lifelines such as Safety and Security, Communications, Food, Water, Sheltering, Transportation, Health and Medical, Hazardous Material (management) and Energy (Power & Fuel).
- Maximize the impact of available funds by **encouraging leverage, public-private partnerships, and coordination** with other federal programs.

RECOVERY PLAN ALIGNMENT:

- **HOU 1** Assess, Repair, Rehabilitate, or Relocate Substantially Damaged Owner-Occupied Homes
- **HOU 3** Make Owner-Occupied Homes More Resilient (Less Vulnerable to Natural Hazards)
- **HOU 5** Collect, Integrate, and Map Housing Sector Data
- **HOU 10** Assess and Renovate Vacant and Blighted Properties
- **CPCB 3** Capacity Building to Incorporate Hazard Risk Reduction into Planning and Design
- **CPCB 4** Resilience Building in Collaboration with High-Risk Communities

[250] The Citizen Advisory Committee is a citizen advisory committee that has been formed under the CDBG-DR program and will be utilized to address both CDBG-DR and CDBG-MIT public information and citizen participation efforts.
[251] PRDOH interprets the word local to mean municipal in this context.

ECONOMIC DEVELOPMENT INVESTMENT PORTFOLIO FOR GROWTH –LIFELINE MITIGATION PROGRAM

RISK-BASED NEED: Private industry owns a large majority of critical and secondary infrastructure assets including, but not limited to, communications towers, privately-owned hospitals and other medical facilities, privately-owned transportation infrastructure, modernized energy solutions that harness the natural resources of Puerto Rico, and privately-owned utilities.

Lifeline strengthening projects coupled with job creation and long-term economic return offer increased resilience benefits for Puerto Rico. The economic impacts of disaster events create a state of crisis for Puerto Rico, reducing the ability of the Government of Puerto Rico and households to take control of their own recovery and mitigation needs. Puerto Rico's ability to bounce back after a disaster event is crippled by the lack of available funds at the state, municipal, and household levels. Mitigation in the shape of economic stability forms the foundation upon which the Island can move toward self-reliance for future disaster events.

PROGRAM DESCRIPTION: The Economic Development Investment Portfolio for Growth – Lifeline Mitigation Program, is a mitigation-focused extension of the CDBG-DR program that will target funding for privately owned lifeline infrastructure to support Risk-Based Mitigation Needs. The launch of this program shall also take into account the changing economic landscape, as benefits of economic recovery efforts tied to the hurricanes are realized.

Revitalizing Puerto Rico through economic investment is more than a program. It is a commitment to the renewal and expansion of quality-of-life opportunities for Puerto Rican citizens, empowering them to own their own recovery from future hazard events. The means to accomplish such a goal are not found in a one-dimensional approach to economic funding, but rather in laying the foundation for ongoing evaluation, planning, and formulation of adaptive investment strategies that take into consideration the economic constraints and opportunities at that time.

Much like CDBG-DR, this mitigation-focused extension of the program is intended to fund large-scale redevelopment projects that are transformative in nature and create jobs as well as cascading economic impacts. Projects under this program are key to a comprehensive mitigation strategy to enable and nurture strategic growth nodes and strengthen economic vitality. The Program also seeks to maximize and bring private development to projects by leveraging Opportunity Zones.[252] where possible.

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[252] On May 14, 2019, the Governor Ricardo Rosselló signed Law 21-2019 to adopt the tax benefits in Puerto Rico that establish the federal Opportunity Zone program. The provisions of Act 21, which were later incorporated into Act 60- 2019, The Puerto Rico Incentives Code, provide local and foreign investors similar tax benefits in Puerto Rico in connection with the deferral and exclusion of certain capital gains if the property is in Puerto Rico. In addition, it establishes a new incentives program for projects that are designated as priority projects and are not eligible for any other incentive program in Puerto Rico.

ELIGIBLE PROJECTS: The objective of this program is to develop a series of projects that foster investment in lifeline infrastructure improvements while creating jobs. This objective may require more distinct requirements for project review and underwriting criteria that differ from CDBG-DR in order to meet the lifeline mitigation targets.

Projects are expected to result in improved outcomes for the lifeline infrastructure described below while generating economic benefit. This may include, but is not limited to the development/redevelopment of:

- Strengthening of resilience corridors within the **Transportation** lifeline to include seaports, airports, and other maritime transportation.
- Large-scale private investment in renewable **energy** projects that capitalize on the natural resources of Puerto Rico and serve to reduce the dependence on fossil fuel to generate energy.[253]
- Improving the resilience of privately owned **Communications** lifeline infrastructure
- Strengthening, modernizing, replacing, or building **water/wastewater** infrastructure to withstand high-risk hazardous activity that poses a threat to asset stability in a disaster event.
- Support food security through agribusiness infrastructure that facilitates the development and indigenous crops resilient to disasters and important to fulfilling food supply needs locally.
- Improving, expanding, or constructing **healthcare and medical** facilities to fortify and innovate buildings and permanent equipment.
- Divert waste from landfills by creating recycling centers or other eco-conscious infrastructure. Improving or fortifying **solid waste** infrastructure within the hazardous waste lifeline to reduce the health threats associated with landfills overfill and instances of clandestine dump sites that only increase with every hazardous event.
- Improving or fortifying **Safety and Security** lifeline infrastructure.

These projects will require large levels of financial investment, of which the CDBG-MIT portion may range from minor to significant. The projects will have a large community impact, whether in terms of job creation, service to the neighborhood, or renewal of a given area. Depending on the nature of the project, they may involve real estate development, whether it is the construction of a new facility or the expansion of an existing building, and will be expected to involve various types of financing and sources of funds. For example, large-scale projects often have a combination of private lender financing, various types of public financing, and business owner cash injections.

This Program will be established for the funding of projects that will significantly impact and enable the long-term economic growth and sustainability of the Island. This program has the capacity to be a funding stream for projects determined by the Government of Puerto Rico to be key drivers for Puerto Rico's new economy and to align with the economic recovery plan. As such, funds will be directed to innovative solutions that are

[253] Projects for alternative energy infrastructure solutions that reduce Puerto Rico's fossil-fuel dependence should apply to the Community Energy and Water Resilience Incentives Program.

forward-looking, cost-efficient, and socially transformative. Additionally, the program expects entities to provide key services related to the project, which will result in the creation of activities that support LMI workers and key strategic growth sectors as outlined in the Recovery Plan and Fiscal Plan.

Projects must contribute to long-term growth potential and modernize privately-owned infrastructure that directly supports one (1) of the seven (7) community lifelines. Such projects must prove to institute one or more of the following mitigation themes:

- **Establish redundancy**: defined as multiple connections to infrastructure lifeline, which prevent the potential consequences of losing service through a single connection.
- **Establish alternatives**: defined as a diverse set of infrastructure types and locations that reduces the danger of overdependence on infrastructure assets that could become single points of failure during emergencies.
- **Establish independence**: defined as local control and management of lifeline assets and infrastructure that can reduce the possibility of widespread systemic failure.
- **Must be based on coordination**: defined as collaboration between communities, industries, governmental entities, and utilities, that proposes changes to critical infrastructure, which would yield more successful outcomes and be more likely to create solutions that meet the needs of communities.

COVERED PROJECTS. For Covered Projects, defined as $50 million dollars or more in total project cost with $25 million dollars or more in match funds from CDBG-MIT, CDBG-DR or CDBG, the project benefits must outweigh the costs. The preferred method for demonstrating this benefit is through the utilization of FEMA's BCA model and the analysis must result in a benefit-to-cost ratio greater than one point zero (1.0). HUD also allows for alternative methods such as[254]:

- A non-FEMA BCA methodology may be used when:
  - o A BCA has already been completed or is in progress pursuant to BCA guidelines issued by other Federal agencies such as the USACE or the DOT;
  - o The alternative BCA method addresses a non-correctable flaw in the FEMA-approved BCA methodology; or
  - o The BCA method proposes a new approach that is unavailable using the FEMA BCA Toolkit.
- In order for HUD to accept any BCA completed or in progress pursuant to another federal agency's requirements, that BCA must account for
  - o economic development,
  - o community development and other social/community benefits, or

[254] United States, Department of Housing and Urban Development, "Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees." 84 FR 45838. (August 30, 2019)

  - o costs and the CDBG–MIT project must be substantially the same as the project analyzed in the other agency's BCA.
- Alternatively, for a Covered Project that serves LMI persons or other persons who are less able to mitigate risks or respond to and recover from disasters, the grantee may demonstrate that benefits outweigh costs using a qualitative description. The grantee completes a BCA as described above, and provides HUD with a benefit-to-cost ratio (which may be less than one), and a qualitative description of benefits that cannot be quantified but sufficiently demonstrate unique and concrete benefits of the Covered Project for LMI persons or other persons who are less able to mitigate risks, or respond to and recover from disasters. This qualitative description may include a description of how the Covered Project will provide benefits such as enhancing a community's economic development potential, improving public health and or expanding recreational opportunities.

ELIGIBLE ACTIVITIES:

- Section 105(a)(1) – Acquisition of Real Property
- Section 105(a)(2) – Public Facilities and Improvements
- Section 105(a)(3) – Code Enforcement
- Section 105(a)(4) – Clearance, Rehabilitation, Reconstruction, and Construction of Buildings
- Section 105(a)(5) – Removal of Material and Architectural Barriers
- Section 105(a)(7) – Disposition of Real Property
- Section 105(a)(8) – Public Services
- Section 105(a)(9) – Payment of Non-Federal Share
- Section 105(a)(11) – Relocation
- Section 105(a)(12) – Planning and Capacity Building
- Section 105(a)(14) – Activities Carried Out through Nonprofit Development Organizations
- Section 105(a)(15) – Assistance to Eligible Entities for Neighborhood Revitalization, Community Economic Development and Energy Conservation
- Section 105(a)(16) – Energy Use Strategies Related to Development Goals
- Section 105(a)(17) – Economic Development Assistance to For-Profit Business
- Section 105(a)(21) – Assistance to Institutions of Higher Education
- Section 105(a)(22) – Microenterprise Assistance

METHOD OF DISTRIBUTION: Direct and Subrecipient Distribution

NATIONAL OBJECTIVE: UNM; LMI job creation

ELIGIBLE ENTITIES:

Public entities that are a part of public-private partnerships for lifeline projects include:

- Units of general local government/ municipalities (including departments and divisions)
- Government of Puerto Rico Agencies, Authorities, Trusts and Boards

- Community-Based Development Organizations and private non-profits
- Non-governmental organization (501©(3)) or other non-profit entities

Privately owned entities include:

- For-Profit Businesses, as eligible under applicable activity

Non-government entities must demonstrate the support of the local municipality (ies) in which the project area and persons of benefit reside, either through formalized consortia or with executed memoranda of agreement (MOA). All applicants will be required to submit an operations and maintenance plan in order to qualify.

MIN AWARD: $500,000

MAX AWARD: $100,000,000. No exceptions to the max award will be considered.

ALIGNMENT WITH CDBG-DR:

- Directly extends the **Economic Development Investment Portfolio for Growth Program** by providing additional funds for economic projects eligible under the program that provide long-term economic resilience potential.
- Increases the reach of resilience improvements initiated under the **Community Energy and Water Installations Program** by requiring new construction to incorporate sustainability measures
- Provides community-based solutions for needs identified through the **MRP Program**
- Further research completed through the **WCRP Program**

ALIGNMENT WITH HUD POLICY OBJECTIVES:

- **Support data-informed investments** in high-impact projects that will reduce risks attributable to natural disasters, with particular focus on repetitive loss of property and critical infrastructure;

- Maximize the impact of available funds by **encouraging leverage, public-private partnerships, and coordination** with other Federal programs.

ALIGNMENT WITH ECONOMIC RECOVERY PLAN:

- **CPCB 3** Capacity Building to Incorporate Hazard Risk Reduction into Planning and Design
- **CPCB 4** Resilience Building in Collaboration with High-Risk Communities
- **CPCB 6** Public Information and Communication Capability for Coordinated Recovery
- **CIT 22** Use Federal Programs to Spur Deployment of Broadband Internet Island-Wide
- **HSS 3** Implement Integrated Waste Management Program and Expand Programs to Increase Recycling Rates
- **PBD 3** Establish Integrated Service Centers
- **TXN 2** Harden Vulnerable Transportation Infrastructure

- **TXN 4** Repair Airport Damage
- **TXN 7** Incentivize a Variety of Mobility Options
- **TXN 10** Develop Redundant Seaport Capacity
- **TXN 12** Repair Damage to Ports and Ferry Terminals
- **TXN 19** Extend PR-5
- **TXN 20** Extend PR-22
- **TXN 21** Complete PR-10
- **TXN 22** Increase Port Facility Resilience
- **ECN 9** Invest in Agricultural Recovery Assistance
- **ECN 23** Implement Job Creation Initiative

COMMUNITY ENERGY AND WATER RESILIENCE INSTALLATIONS PROGRAM

RISK-BASED NEED: Historically, it's been proven that the legacy energy infrastructure in Puerto Rico is unreliable and does not meet the needs of citizens. This reality is made clear when a disaster event occurs and prolonged power outages pose health and safety threats that increase every day as the power and the services it fuels, remain unavailable to households, hospitals, and critical services facilities. Citizens must have additional options to meet this critical need.

Water and wastewater infrastructure in Puerto Rico is largely centralized as well. The state agency PRASA provides drinking water to most Puerto Rico residents, approximately 76,000 residents in over 200 small communities are serviced by non-PRASA drinking water suppliers. Sources estimate there to be approximately 242 non-PRASA community drinking water systems.[255] These systems serve small and potentially hard-to-reach populations. In addition, fifty-seven (57) noncommunity systems in Puerto Rico provide drinking water to hospitals, schools, industrial facilities, and private companies.

The fragile and aging Energy[256] and Water and Wastewater[257] sector infrastructure, and lack of access to quality utilities for remote communities, each pose a threat to basic service utilities that generate, store, and distribute essential products to the people of Puerto Rico.

As established in the Risk Assessment, Energy and Water and Wastewater lifeline sectors are central to the stability of Puerto Rican communities. The Energy sector and the Water and Wastewater Systems sector have significant interdependencies: water is used in all phases of energy production and electricity generation, while electricity and other fuels are used to extract, convey and deliver water, and to treat wastewater, prior to its return to the environment. Fragility within these lifeline sectors makes them extremely vulnerable to naturally occurring and human-caused hazards in that localized events can cause a systemic and cascading failure. Both the electric grid and water infrastructure are aged and costly to redevelop.

For both industries, a micro-utility structure such as micro or mini grids offer a potential solution to provide redundancy, fortify system vulnerabilities on a localized level, and through the incorporation of renewables, reduce dependence on the resource supply chain. Micro-utility solutions, along with the installation of equipment for households and businesses, offer a modern and sustainable solution to mitigate the risk of instability from legacy infrastructure components. This approach furthers the mitigation strategy to invest in redundancy, alternatives, and independence.

[255]G. I. Ramirez-Toro and H. Minnigh, "Water System Resilience in Disasters: Puerto Rico's Experience," presented at Water Science and Technology Issues for the Nation.
[256] The power grid is a main sector within the Energy lifeline
[257] Lifeline sector within the Food, Water, and Shelter Lifeline

Need for Energy Resilience. Energy is the one lifeline upon which all others depend; yet it is primarily dependent on imported fossil fuel sources. Ninety-eight percent (98%) of the power grid functions on gasoline, coal, and natural gas, while only two percent (2%) functions on renewable sources. A continuation of this dependence, coupled with a centralized system of fragile infrastructure, could likely be the single most significant obstacle to resilience for Puerto Rico. Furthermore, emergency generators are a prevalent solution for backup energy in the event the power grid becomes unstable, but they also depend on imported fuels and a functioning complex supply chain.

At this pivotal point in time when Puerto Rico is expecting billions of dollars[258] for energy grid repair and improvements, PRDOH is focusing critical mitigation funds on the resilience of communities and individual households by furthering the goals set by the Puerto Rico Energy Public Policy Act, Law 17-2019, which sets the Island on a path to forty percent (40%) and one hundred percent (100%) renewable energy by 2025 and 2050, respectively.

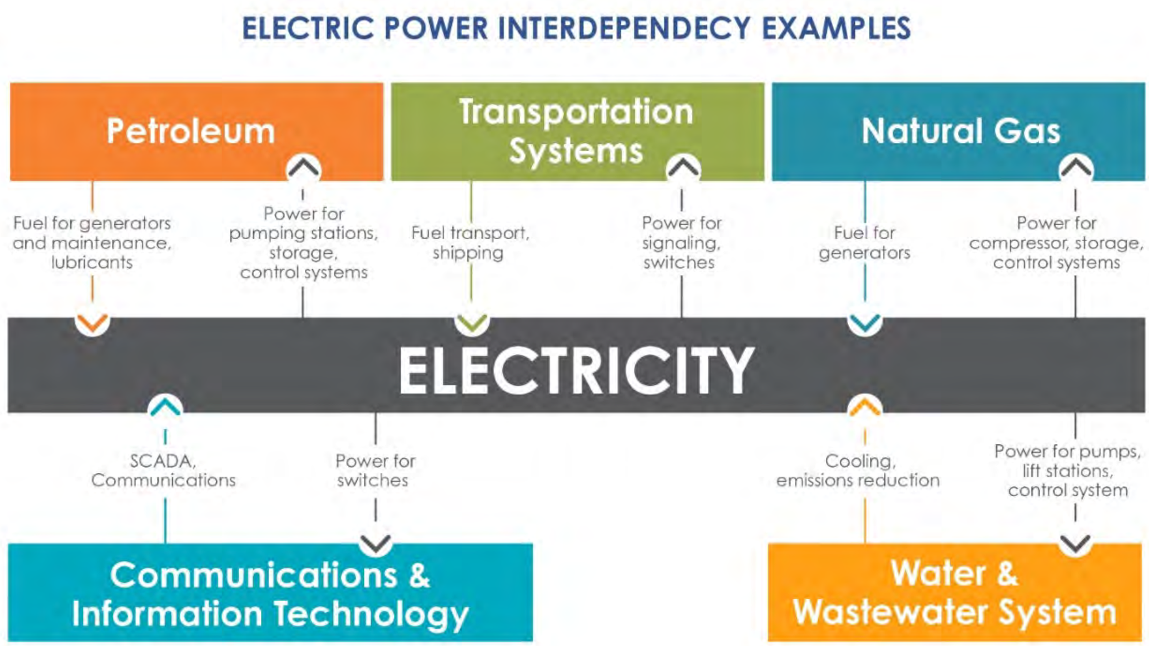

Figure 88. Illustration of how the power grid dependence on fossil fuel creates an interwoven vulnerability for other lifelines that depend on the power grid to function. Source: US Department of Energy, "Energy Resilience Solutions for the Puerto Rico Grid"

The necessity for redundant, alternative, and independent power systems, remains an unmet need today, and will continue to represent an unmet need long after Puerto Rico can implement the forthcoming $2 billion energy system allocation from HUD.

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[258] As a result of Hurricanes Irma and María, HUD has acknowledged an almost $2 billion unmet need to the energy grid, and the Government of Puerto Rico in consultation with PREPA originally estimated $17 billion need to overhaul its outdated power plants and reduce its reliance on imported oil. Billions in federal funding have been expended on repairs yet Island-wide power outages continue to contribute to an unmet need for reliable power.

Need for resilience and increased access to Water & Wastewater services. A prevalent topic that arose during stakeholder discussions for this Action Plan, considered the need for long-term sustainable water and wastewater solutions for the 242 communities that are not currently served by PRASA. These communities may or may not currently be served by Onsite Wastewater Systems (OWS) or wastewater infrastructure not connected to PRASA.

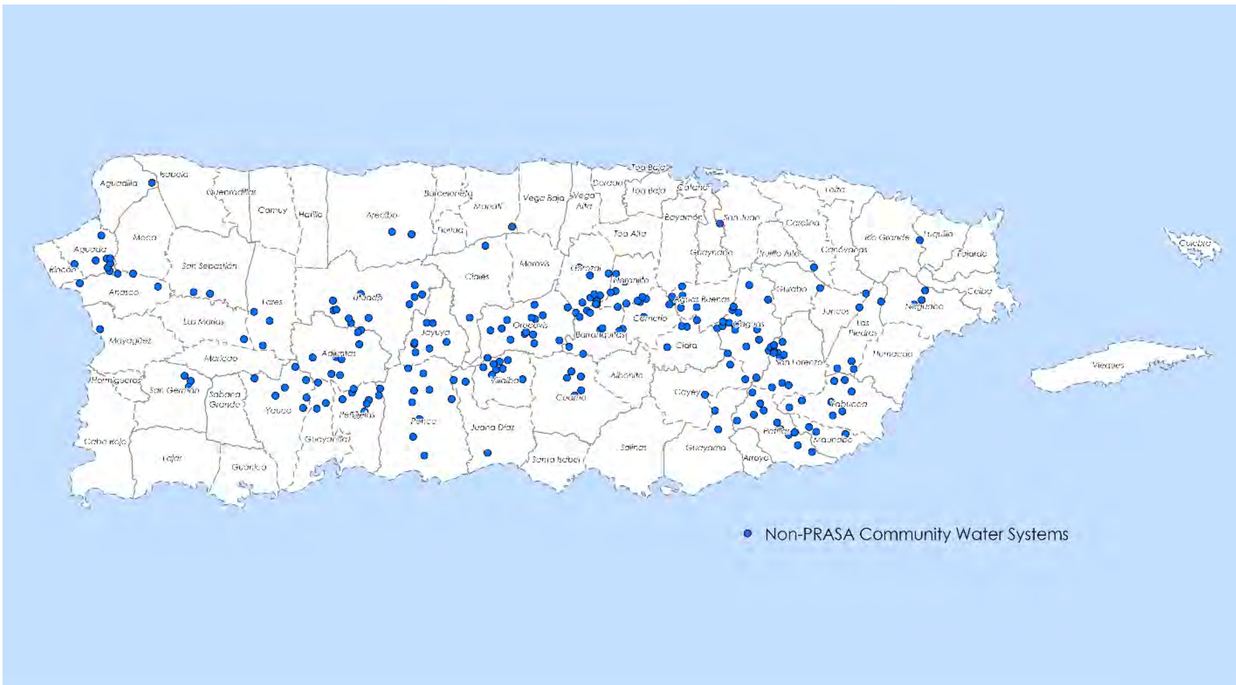

Figure 89. Non-PRASA Community Water Systems

Community-level solutions for water and wastewater sector infrastructure must consider community-based mitigation needs to determine whether the installation of centralized utility lines and service under PRASA are the most appropriate solution or if a localized mini grid better serves a community's mitigation needs by reinforcing opportunities for redundancy, alternatives, and/or independence.

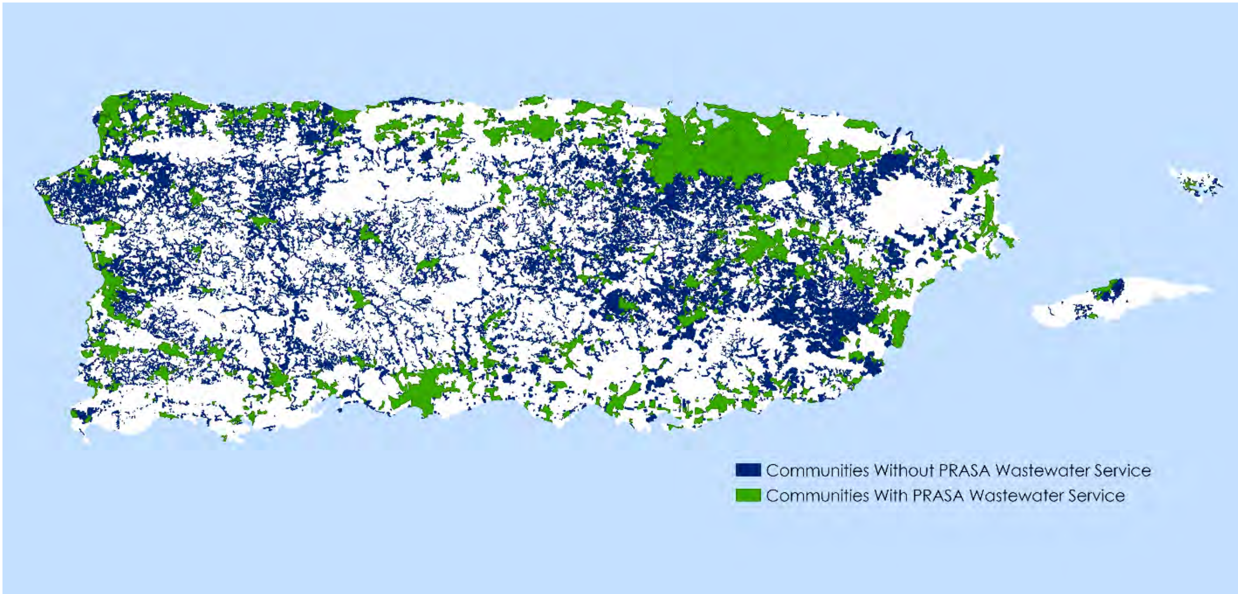

Figure 90. Map image of Puerto Rican communities that are within or outside of the PRASA utility service area for wastewater management.

PROGRAM DESCRIPTION: There are three (3) subprograms within the Community Energy and Water Resilience Installations Program (**CEWRI**):

I. HOME ENERGY AND WATER RESILIENCE IMPROVEMENTS. *Max Award: $30,000*. Homes unprepared for the natural threats on the power grid were left vulnerable in the aftermath of Hurricanes Irma and María. Rebuilding to protect federal investment and to sustain recovery efforts requires resilient design and improvements that incorporate modern technology for life-sustaining purposes during off-grid events. Energy and water resilience efforts may include conducting a home energy evaluation and the promotion of energy efficiency and stability. Resilient design and improvements include things such as the installation of photovoltaic systems, solar generators, and battery storage at capacities aligned with household needs, including the consideration of critical medical needs.

Eligible applicants to this Program must own a single-family home structure in which a full-time resident resides, either the owner or a renter. Households must also be below eighty percent (80%) AMFI.

Priority will be given to:

- Elderly residents (sixty-five (65) years old or older)
- Critical Recovery Workforce (**CRW**) personnel[259]

[259] This includes first responders (i.e., emergency management personnel such law enforcement officers and firefighters, emergency shelter support staff, etc.), and medical personnel including support staff (i.e., respiratory technicians, phlebotomists, lab and x-ray technicians, and nutritionists). Critical Recovery Workforce will be futher defined in the Program Guidelines.

- Residents with high risk energy and water security.[260]

II. COMMUNITY INSTALLATIONS. *Max Award: $2,000,000*. Community installations of energy production and storage, water catchment systems, and sanitary sewer system solutions may be offered in order to complement home-based improvements or reduce household barriers to mitigation. Community installations may include larger kilowatt, bimodal systems that can support health, lighting, communication, and other backup energy needs of area residents. Community-based systems may also include public microgrids. Community-based water security interventions may be introduced, similarly, where a greater community need may be met, where more localized interventions are less feasible or cost-efficient, and in particular where the community is not part of the island-wide water supply system (e.g. non-PRASA communities). For both energy and water resilience efforts, these installations may be introduced in areas where housing typologies or existing structures cannot accommodate solar panels or water systems, or where a larger scale typology is more cost-efficient to serve the community.

Entities eligible to apply to this Program include:

- Units of general local government/ Local and Municipal Governments (including departments and divisions)
- Community-Based Development Organizations and private not-for-profits
- Non-governmental organization (501©(3)) or Not for Profit Entities

Non-government entities must demonstrate the support of the local municipality (ies) in which the project area and persons of benefit reside, either through formalized consortia or with executed memoranda of agreement (MOA). All applicants will be required to submit an operations and maintenance plan in order to qualify.

Community applicants will be required to submit a long-term operations and maintenance plan that addresses the operations and maintenance costs of the energy and/or water and wastewater infrastructure improved. All applicants are required to submit a long-term operations and maintenance plan and must identify reasonable milestones for any plan that will be reliant on proposed changes to existing taxation policies or tax collection practices.

Priority will be given to:

- Communities with fifty-one percent (51%) LMI beneficiaries (households below eighty percent (80%) AMFI)
- Communities with high risk energy and water security
- Communities not served by PRASA systems will be prioritized for water and wastewater solutions

[260] High risk considers residents whose life expectancy is directly affected by the loss of power or water. (i.e., Residents with a need to refrigerate medications such as insulin and run medical equipment such as oxygen machine and nebulizers, would be considered high-risk). This will be further defined in the Program Guidelines.

III. INCENTIVE PROGRAM. *Max Award: $15,000 per household; $1,500,000 per business.* An incentive program covering up to the lessor of seventy-five percent (75%) or $15,000 of household project costs will be offered to enable the installation of renewable energy systems, including storage, which will be interconnected to the actual energy grid. This Program is available to residents and small to mid-sized businesses. This Program in particular is a viable option for assistance to the telecommunications sector in that privately-owned utilities of the Communications lifeline depend on energy to function.

Eligible applicants may include the owner of a single-family residential structure, or a business that supports, either directly or indirectly, one (1) of the seven (7) community lifelines. Businesses will be required to submit an operations and maintenance plan in order to qualify.

Priority will be given to:

- First priority will be given to households below eighty percent (80%) AMFI
- First priority will be given to business applicants with privately-owned infrastructure that directly supports one (1) of the seven (7) community lifelines
- Second priority will be given to business applicants that provide a public service benefit that directly or indirectly supports one (1) of the seven (7) community lifelines

ELIGIBLE ACTIVITIES:

- Section 105(a)(4) – Housing Construction, Acquisition, Green Building Standards
- Section 105(a) (15); – Public Facilities and Public Service – 24 C.F.R. § 570.201

INELIGIBLE ACTIVITIES:

- Activities that directly improve the power grid infrastructure – not to be confused with local renewable system tie-ins.
- Installation of equipment that is not permanent and integral to the structure – as defined by The Puerto Rico Civil Code in Article 261 and Article 263.

METHOD OF DISTRIBUTION: Direct and Subrecipient Distribution Model

NATIONAL OBJECTIVE: UNM; LMI

MIN AWARD: Based on cost reasonableness analysis.

MAX AWARD: Variable (see above). Policy exceptions for a max award will be considered by the PRDOH Special Review panel and shall not exceed ten percent (10%) of the project value. Exceptions will be evaluated based on need which may include the number of beneficiaries, the profile of historical losses from past disaster events, operations and maintenance plan, and long-term mitigation potential.

No exceptions to the max award will be considered.

ALIGNMENT WITH CDBG-DR PROGRAMS:

- Increases the reach of resilience improvements initiated under the **CEWRI Program.**
- Provides community-based solutions for needs identified through the **MRP Program**.

ALIGNMENT WITH HUD POLICY OBJECTIVES:

- **Support data-informed investments** in high-impact projects that will reduce risks attributable to natural disasters, with particular focus on repetitive loss of property and critical infrastructure.
- **Support the adoption of policies** that reflect local[261] and regional priorities that will have long-lasting effects on community risk reduction, to include the risk reduction to community lifelines such as Safety and Security, Communications, Food, Water, Sheltering, Transportation, Health and Medical, Hazardous Material (management) and Energy (Power & Fuel).
- Maximize the impact of available funds by **encouraging leverage, public-private partnerships, and coordination** with other Federal programs.

ALIGNMENT WITH ECONOMIC RECOVERY PLAN:

- **CPCB 4** Resilience Building in Collaboration with High-Risk Communities
- **WTR 3** Enhance the Efficiency and Resilience of PRASA Electricity Services
- **WTR 12** Enhance Electricity Reliability and Redundancy for Non-PRASA and Nonregulated Systems
- **WTR 14** Improve Equity in Drinking Water Provision for Nonregulated Systems
- **WTR 15** Improve Reliability and Safety of Non-PRASA Systems
- **WTR 16** Build Capacity of Non-PRASA Systems
- **HSS 1** Increase Use of Solar-Powered Generators and Solar Backup Power Sources

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[261] PRDOH interprets the word local to mean municipal in this context.

CITIZEN PARTICIPATION

CITIZEN PARTICIPATION

The citizen participation protocols described in this Action Plan are further detailed in the PRDOH Citizen Participation Plan which provides all Puerto Rican residents with an opportunity to participate in the planning and assessment of the PRDOH's CDBG-MIT programs.

Methods for Citizen Participation

The following paragraphs describe methods that will be used for citizen participation in relation to the CDBG-MIT programs. The methods described are not intended to be exclusive of other methods of citizen participation allowed by HUD.

Methods and Opportunities for Citizen Involvement:

- Public Hearings;
- Communication Via the Internet;
- Information via the PRDOH Website;
- Citizen Advisory Committee(s);
- Participatory Engagement; and
- Other Methods for Citizen Participation

Through these methods, citizens may receive information about the following:

- The amount of assistance available to impacted communities;
- The range of eligible activities to be undertaken;
- Performance reports;
- Action Plan and Action Plan Amendments and comment periods;
- Program information, including how to request additional information;
- Upcoming Public Hearings, Webinars or other stakeholder sessions;
- The Citizen Advisory Committee, including its Subcommittees;
- Information to request and receive technical assistance;
- How to comment on the Citizen Participation Plan; and
- How to file a complaint.

Public Hearings

HUD guidance at 84 FR 45838, 45843 prescribes for CDBG-MIT grantees the number of public hearings that must be convened, based upon the amount of the grantee's allocation. PRDOH adheres to the guidelines for allocations of $1 billion or more requiring at least four (4) public hearings in the HUD-identified most impacted and distressed area with at least two (2) of these public hearings occurring prior to the publication of the Action Plan for public comment. Since all of Puerto Rico has been designated by HUD as most impacted and distressed, PRDOH will select locations within each of the four (4) housing regions[262] utilized for the CDBG-DR Program to hold public hearings, public health conditions permitting (see Location of Public Hearings section below). The CDBG-MIT Action Plan public comment period will be open for no less than **forty-five (45) calendar days**.

It's important to note that Public Safety is a priority concern for PRDOH, its employees, and the citizens it serves. Given the current situation with COVID-19, PRDOH is embracing the most robust use of technology for stakeholder and public meetings. Acknowledging the safe practice of social distancing, PRDOH will be conducting public hearing events through a web-based participation platform that allows for citizen engagement in real time.

Due to the COVID-19 health concerns, in early 2020 HUD provided guidance regarding alternative allowable measures related to public hearing requirements. In accordance with that guidance, and in lieu of the ability to conduct in-person events, if PRDOH chooses to conduct a public hearing, PRDOH will use mechanisms such as social media platforms and/or radio broadcasts to conduct public hearings. Residents will have the option of submitting comments during the public hearings through one or more of the following, including the CDBG-DR website, webinar chat functions, radio call-ins, comments on social media and through the call center (1-833-234-CDBG or 1-833 234-2324, (TTY: 787-522-5950). Recordings of these events would be made available on the PRDOH website and/or social media within **five to ten (5-10) business days** of the event.

In HUD's *CDBG-DR COVID 19 Fact Sheet*[263] published March 20, 2020, and updated May 4, 2020, HUD released guidance to Puerto Rico and US Virgin Islands on modifications to public participation and public hearings. In this FAQ release, HUD acknowledges that "…[I]f a grantee is concerned about significant public health risks that may result from holding in-person public hearings, CPD is interpreting public hearings in the context of the CDBG-MIT Federal Register notice to include virtual public hearings (alone, or in concert with an in-person hearing) if it allows questions in real-time, with answers coming directly from the elected representatives to all "attendees." HUD understands the exigencies of a public health challenge and will work with grantees who make the effort to comply with citizen participation requirements and documents their efforts."

Communication for Individuals with Disabilities

PRDOH is committed to ensuring that citizens with disabilities also have effective means to participate and communicate with PRDOH. Consequently, PRDOH will also effectively communicate with citizens with disabilities regarding Action Plans, policies and procedures. Interpretation services for sign language will be made available at Public Hearings. Notices for public meetings will include contact information for requesting

[262] For details about the regions and locations utilized to hold public hearings in the CDBG-DR Program, please refer to the CDBG-DR Action Plan. However, these regions could change according to the needs of CDBG-MIT.
[263] HUD, CDBG-DR COVID-19 Fact Sheet, published March 20, 2020, updated July 24, 2020, accessed at the following: https://www.hud.gov/sites/dfiles/CPD/documents/COVID-19-CDBG-DR-FAQs-072420.pdf

accessible communication aids or services, which should be requested at least **forty-eight (48) hours** in advance of the meeting time.

The Action Plan and other materials on the PRDOH website are provided in accessible formats, including those readable by screen readers to provide accessibility to the visually impaired. PRDOH will meet communications requirements at 24 C.F.R. 8.6 and other Fair Housing and civil rights requirements, such as the effective communication requirements under the Americans with Disabilities Act of 1990.

The CDBG-DR Fair Housing and Equal Opportunity Policy and its appendices, will be posted along with all CDBG-DR Program policies in English and Spanish at https://www.cdbg-dr.pr.gov/en/resources/policies/general-policies/ and https://www.cdbg-dr.pr.gov/recursos/politicas/politicas-generales/. The same Fair Housing and Equal Opportunity Policy shall be adopted for the CDBG-MIT Program upon HUD's approval of the Action Plan.

Program accessibility for individuals with disabilities may be requested at:

- Via telephone: 1-833-234-CDBG o 1-833-234-2324 (TTY: 787-522-5950)
  Attention hours: Monday to Friday from 8:00am-5:00pm
- Via email at: infoCDBG@vivienda.pr.gov – for all CDBG-DR inquiries, or
  CDBG-MIT@vivienda.pr.gov – for all CDBG-MIT inquiries
- Online at: https://www.cdbg-dr.pr.gov/en/contact/ (English version)
  https://www.cdbg-dr.pr.gov/contact/ (Spanish version)
- In writing at:

  Puerto Rico CDBG-DR Program/CDBG-MIT Program

  P.O. Box 21365

  San Juan, PR 00928-1365

Citizen Involvement in the Original Action Plan

The original Action Plan will be posted in English and Spanish to the PRDOH program website www.cdbg-dr.pr.gov to allow an opportunity for public comment for no less than **forty-five (45) calendar days** for CDBG-MIT, as required by 84 FR 45838. The posting will also be communicated via e-mail, and/or postal mail, to non-profit organizations who work with vulnerable populations, municipalities, elected officials, and others, and will be announced through the PRDOH social media site on Facebook. PRDOH will consider comments on the Action Plan or substantial amendments received in writing, via email, verbally via the Call Center or expressed in-person or at official public hearing events.

Additionally, in an effort to permit public examination and accountability, PRDOH will make formal comments regarding Action Plans or substantial amendments publicly available at www.cdbg-dr.pr.gov/en/action-plan/ in English and at https://www.cdbg-dr.pr.gov/plan-de-accion/ in Spanish. PRDOH responses to comments regarding Action

Plans or substantial amendments will also be posted to the website. PRDOH will submit the summary of these comments or views, and its response to each comment to HUD with the Action Plan or substantial amendment.

Citizens accessing information via the CDBG-MIT website in English and Spanish at https://cdbg-dr.pr.gov/en/cdbg-mit/ and https://cdbg-dr.pr.gov/cdbg-mit/ and who are seeking to comment on the CDBG-MIT Action Plan will be directed to the Action Plan links for public comment as outlined above.

The most current version of the approved Action Plan, including any substantial amendments, will be posted as a single document and located at: https://www.cdbg-dr.pr.gov/en/action-plan/ in English and https://www.cdbg-dr.pr.gov/plan-de-accion/ in Spanish. Posting the Action Plan and any amendments as a single document allows the public to view the Action Plan as a whole, rather than the public having to view and cross-reference changes among multiple amendments. Citizens who cannot access the Action Plan or proposed substantial amendments through the website may request assistance from PRDOH:

- Via telephone: 1-833-234-CDBG or 1-833-234-2324 (TTY: 787-522-5950)
  Attention hours: Monday to Friday from 8:00am-5:00pm
- Via email at: CDBG-MIT@vivienda.pr.gov – for all CDBG-MIT inquiries
- Online at: https://www.cdbg-dr.pr.gov/en/contact/ (English version)
  https://www.cdbg-dr.pr.gov/contact/ (Spanish version)
- In writing at: Puerto Rico CDBG-MIT Program
  P.O. Box 21365
  San Juan, PR 00928-1365

Citizen Involvement in the Substantial Amendment Process

Substantial amendments are subject to a **thirty (30) calendar day** public comment period, and shall be posted to the PRDOH website where citizens will also be able to submit electronic comments, or follow instructions for submitted written comments, by alternative means listed on the website.

Citizen participation for substantial amendments to the Action Plan will follow this PRDOH Citizen Participation Plan. Changes made via substantial amendments to the Action Plan will be highlighted or otherwise identified within the context of the entire Action Plan. As required by 84 FR 45838, 45850, every substantial amendment will include the following:

- A section that identifies what content is being added, deleted or changed;
- Chart or table that clearly illustrates where funds are coming from and where they are moving to; and

- Revised budget allocation table that reflects all funds.

A substantial amendment is defined as an amendment that contemplates one (1) or more of the following:

- The addition of a covered project (applicable to CDBG-MIT only);
- Change in a program benefit or eligibility criteria;
- Addition or deletion of an activity; and
- Allocation or reallocation of more than ten percent (10%) of grant funds.

Non-substantial Amendments to this Action Plan are not subject to a public comment period and will, therefore, follow HUD procedure requiring PRDOH to notify HUD at least **five (5) business days** before the amendment becomes effective. All non-substantial amendments will be posted to the PRDOH public website with changes to the text highlighted in grey.

Consideration of Public Comments

PRDOH will consider comments on the Action Plan or substantial amendments received in writing, via email, verbally via the Call Center or expressed in - person or at official public hearing events. Additionally, in an effort to permit public examination and accountability, PRDOH will make formal comments regarding Action Plans or substantial amendments publicly available at www.cdbg-dr.pr.gov/en/action-plan/ in English and at https://www.cdbg-dr.pr.gov/plan-de-accion/ in Spanish. PRDOH responses to comments regarding Action Plans, or substantial amendments, will also be posted to the website.

Communication via the internet

Public information for CDBG-MIT during Action Plan development can be found on a dedicated page within the CDBG-DR Program website in English and Spanish at https://cdbg-dr.pr.gov/en/cdbg-mit/ and https://cdbg-dr.pr.gov/cdbg-mit/. From this page, entity and private citizen stakeholders can find more information, register for program-related notifications, and find a formal announcement for the opening of the CDBG-MIT Action Plan public comment period.

The CDBG-MIT Action Plan will be posted in its entirety to the CDBG-DR Action Plan and amendments page where all versions of the CDBG-DR Action Plan are currently located and future CDBG-MIT Action Plan and amendments will reside in English and Spanish at: https://cdbg-dr.pr.gov/en/action-plan/ and https://www.cdbg-dr.pr.gov/plan-de-accion/.

Once the CDBG-MIT Action Plan is approved by HUD and additional program becomes available, all information will be integrated into the current CDBG-DR site.

Interested individuals are encouraged to comment at any time by sending an email to CDBG-MIT@vivienda.pr.gov for CDBG-MIT inquiries. Additionally, citizens may comment by using the "Contact Us" tool included in PRDOH's disaster recovery website. The "Contact Us" tool can be accessed directly at www.cdbg-dr.pr.gov/contact/ in English and https://www.cdbg-dr.pr.gov/contact/ in Spanish.

As part of the implementation of CDBG-MIT Programs, PRDOH will regularly interact with municipalities, NGOs and the citizens of Puerto Rico. These methods may include but are not limited to:

- Web-based surveys
- Coordination with municipalities, non-profit or community organizations, faith-based or other organizations
- Focus groups or interviews
- Other in-person meetings as requested by individuals or organizations.

This Citizen Participation Plan will continue to be updated as programs progress. Citizen comment is welcome on this Plan throughout the duration of this grant. Please contact PRDOH using the following methods:

- Via telephone: 1-833-234-CDBG or 1-833-234-2324 (TTY: 787-522-5950)
  Attention hours: Monday to Friday from 8:00am-5:00pm
- Via email at: CDBG-MIT@vivienda.pr.gov – for all CDBG-MIT inquiries
- Online at: https://www.cdbg-dr.pr.gov/en/contact/ (English version)
  https://www.cdbg-dr.pr.gov/contact/ (Spanish version)
- In writing at: Puerto Rico CDBG-MIT Program
  P.O. Box 21365
  San Juan, PR 00928-1365

Citizen Advisory Committee

As per federal requirements for CDBG-MIT, a Citizen Advisory Committee shall be formalized once the CDBG-MIT Action Plan has been approved. Per HUD guidance at 84 FR 45838, 45853, the Committee shall meet in an open forum, not less than twice annually, in order to provide increased transparency in the implementation of CDBG–MIT funds. The Committee will solicit and respond to public comment and input regarding PRDOH's mitigation activities and serve as an on-going public forum to continuously inform the PRDOH CDBG–MIT projects and programs. These meetings will provide the opportunity to solicit and respond to public comments on the mitigation activities.

Performance Report

Program performance reports, such as Quarterly Performance Reports (QPR), will be posted at https://www.cdbg-dr.pr.gov/en/reports/ prior to submission to HUD. Citizens will be provided **fifteen (15) calendar** days to comment on performance reports, as required by 2 C.F.R. § 91.115.

Please contact PRDOH using the following methods:

- Via telephone: 1-833-234-CDBG or 1-833-234-2324 (TTY: 787-522-5950)
  Attention hours: Monday to Friday from 8:00am-5:00pm
- Via email at: CDBG-MIT@vivienda.pr.gov – for all CDBG-MIT inquiries
- Online at: https://www.cdbg-dr.pr.gov/en/contact/ (English version)
  https://www.cdbg-dr.pr.gov/contact/ (Spanish version)
- In writing at: Puerto Rico CDBG-MIT Program
  P.O. Box 21365
  San Juan, PR 00928-1365

Individuals with Limited English Proficiency

Program materials, including plans and program guidelines, will be available in Spanish and English at https://cdbg-dr.pr.gov/en/ and Spanish https://cdbg-dr.pr.gov/. For access to language access services in languages other than English or Spanish, citizens may contact PRDOH at:

- Via telephone: 1-833-234-CDBG or 1-833-234-2324 (TTY: 787-522-5950)
  Attention hours: Monday to Friday from 8:00am-5:00pm
- Via email at: CDBG-MIT@vivienda.pr.gov – for all CDBG-MIT inquiries
- Online at: https://www.cdbg-dr.pr.gov/en/contact/ (English version)
  https://www.cdbg-dr.pr.gov/contact/ (Spanish version)
- In writing at: Puerto Rico CDBG-MIT Program
  P.O. Box 21365
  San Juan, PR 00928-1365

Materials will also be disseminated among program partners, including municipalities, government agencies, non-profit organizations, and NGOs to ensure that these materials are accessible locally.

The CDBG-DR Language Access Plan will be posted, along with all CDBG-DR Program policies, in both English and Spanish languages at URL:

https://www.cdbgdr.pr.gov/en/resources/policies/general-policies/ and at https://www.cdbgdr.pr.gov/recursos/politicas/politicas-generales/.

Technical Assistance

PRDOH will provide technical assistance in order to facilitate public participation regarding CDBG-DR and CDBG-MIT Programs, upon request. Technical assistance provided will be determined based on the needs of the community or individual requesting assistance. This technical assistance may be requested at:

- Via telephone: 1-833-234-CDBG or 1-833-234-2324 (TTY: 787-522-5950)
  Attention hours: Monday to Friday from 8:00am-5:00pm
- Via email at: CDBG-MIT@vivienda.pr.gov – for all CDBG-MIT inquiries
- Online at: https://www.cdbg-dr.pr.gov/en/contact/ (English version)
  https://www.cdbg-dr.pr.gov/contact/ (Spanish version)
- In writing at: Puerto Rico CDBG-DR Program/CDBG-MIT Program
  P.O. Box 21365
  San Juan, PR 00928-1365

Accessibility of Information

Information related to PRDOH's CDBG-DR and CDBG-MIT, including Action Plans, Action Plan amendments, program policies and procedures, performance reports, citizen participation requirements, program information, and details of contracts and ongoing procurement policies will be publicly available in English and Spanish at www.cdbg-dr.pr.gov. Program information posted to the website will be accessible and available in both Spanish and English and will be made available in accessible formats, including those readable by screen readers. PRDOH will make information available in alternate formats as needed and upon request, to ensure effective communication to persons with disabilities.

PRDOH may use a variety of communication methods to notify the public of information regarding the CDBG-DR and CDBG-MIT Programs. The methods listed have been used by PRDOH prior to the disaster to communicate information across the Island. The use of these methods varies based on region and municipality. In addition to these methods of outreach and an active online presence, PRDOH regularly provides CDBG-DR written outreach materials for all municipalities to use and communicate to their constituents. These methods may include, but are not limited to:

- Print media, such as the newspaper;
- Social media;

- Radio or television advertisements;
- Letters or emails to municipalities, government agencies, non-profit organizations and NGOs;
- Notices posted to internet sites, including PRDOH's CDBG-DR and CDBG-MIT websites;
- Ads on billboards and bus stops;
- "Tumba coco" (a popular local method for communication which includes a vehicle with speakers used for promotion);
- Brochures and printed materials;
- Direct mail;
- Outbound call campaigns (live or automated);
- Email announcements;
- Community events or fairs;
- Webinars or web conferences;
- Web-based surveys;
- Focus groups or interviews;
- Community meetings;
- Press releases;
- Media events or interviews; and
- Other forms of communication accepted by HUD.

PRDOH will continue to coordinate outreach meetings with municipalities, government agencies, non-profit and community organizations, and other interested stakeholders to disseminate information related to the PRDOH Action Plan or substantial Action Plan amendments.

To promote access to information among low- or moderate-income citizens, PRDOH will organize special orientation events throughout the Island or use broad-band media campaigns, once the launch of the first CDBG-MIT fund program is completed and dissemination initiatives begin. The use of direct communication with municipalities, government agencies, non-profit organizations and NGOs as partners is intended to increase residents' access to information and is supplemental to communication between PRDOH and residents. In addition to citizen involvement, PRDOH encourages the participation of regional and island-wide institutions.

Simultaneously with the abovementioned efforts, PRDOH will distribute informational material through its regional offices and public residential administrators and strengthen the distribution of news information on the programs through regional media that operate in areas where CDBG-DR and CDBG-MIT funds will intervene. This is in accordance with the Plan's initiatives aimed to strengthen access to information among low- or moderate-income citizens and members of minority or disabled groups.

Citizen Complaints

As part of addressing Puerto Rico's long-term recovery needs, citizen complaints on any issues related to the general administration of CDBG-DR and CDBG-MIT funds are welcome throughout the duration of the grant. PRDOH aims to provide an opportunity to address all complaints received. Addressing these complaints is an essential responsibility for PRDOH, as it establishes the importance of open communication regarding citizens' concerns about the programs.

It is PRDOH's responsibility, as grantee, to ensure that all complaints are dealt with promptly and consistently and at a minimum, to provide a timely, substantive written response to every **written** complaint within **fifteen (15) business days**, where practicable, as a CDBG grant recipient. See 24 C.F.R. § 570.486(a) (7).

PRDOH aims to provide an opportunity to address all complaints received, either formally or informally. An informal complaint refers to those complaints that are verbally communicated through PRDOH program personnel. These are not subject to 24 C.F.R. § 570.486(a) (7), unless the complainant requests for it to be filed as a formal complaint. A formal complaint is a written statement of grievance. All formal complaints will be documented, processed, filed and answered. Complaints with insufficient data or submitted by a third party with no standing in the matter being submitted need not be accepted or reviewed.

Citizens who wish to submit formal complaints related to the CDBG-MIT funded activities may do so through any of the following means:

- Via email at: LegalCDBG@vivienda.pr.gov
- Online at: https://cdbg-dr.pr.gov/en/complaints/ (English)
  https://cdbg-dr.pr.gov/quejas/ (Spanish)
- In writing at: Puerto Rico CDBG-DR Program/CDBG-MIT Program
  Attn: CDBG-DR/MIT Legal Division- Complaints
  P.O. Box 21365
  San Juan, PR 00928-1365

Although formal complaints are required to be submitted in writing, complaints may also be received verbally and by other means necessary, as applicable, when PRDOH determines that the citizen's particular circumstances do not allow the complainant to submit a written complaint. However, in these instances, PRDOH shall convert these complaints into written form. These alternate methods include, but are not limited to:

- Via telephone*: 1-833-234-CDBG or 1-833-234-2324 (TTY: 787-522-5950)
  Attention hours: Monday to Friday from 8:00am-5:00pm
- In-person at: PRDOH Headquarters Office or Program Intake Centers

The Citizen Complaints Policy and all CDBG-DR and CDBG-MIT Program policies are posted in both English and Spanish languages at https://www.cdbg-dr.pr.gov/en/resources/policies/general-policies/ and https://www.cdbg-dr.pr.gov/recursos/politicas/politicas-generales/. All policies that pertain to the CDBG-DR program carry over to CDBG-MIT unless otherwise clarified in the document.

Citizen Complaints for Anti-Fraud, Waste, Abuse or Mismanagement

PRDOH, as grantee, is committed to the responsible management of CDBG-DR and CDBG-MIT funds by being a good advocate of the resources while maintaining a comprehensive policy for preventing, detecting, reporting and rectifying fraud, waste, abuse, or mismanagement.

Pursuant to 83 FR 40314 for CDBG-DR, and 84 FR 45838 and Special Conditions in 85 FR 4676 for CDBG-MIT, PRDOH implements adequate measures to detect and prevent fraud, waste, abuse, or mismanagement in all Programs administered with CDBG-DR funds. It also encourages any individual who is aware, or suspects, any kind of conduct or activity that may be considered an act of fraud, waste, abuse, or mismanagement, regarding the CDBG-DR Program, to report such acts to the CDBG-DR Internal Audit Office, directly to the Office of Inspector General (OIG) at HUD, or any local or federal law enforcement agency.

The Anti-Fraud, Waste, Abuse, or Mismanagement Policy (**AFWAM Policy**) is established to prevent, detect and report any acts, known or suspected, of fraud, waste, abuse, or mismanagement of CDBG-DR and CDBG-MIT funds. This Policy applies to any allegations or irregularities, either known or suspected, that could be considered acts of fraud, waste, abuse, or mismanagement, involving any citizen, previous, current or potential applicant, beneficiary, consultant, contractor, employee, partner, provider, subrecipient, supplier, and/or vendor under the CDBG-DR and CDBG-MIT Programs.

REPORT FRAUD, WASTE, ABUSE, OR MISMANAGEMENT TO PRDOH	
CDBG-DR Hotline	787-274-2135 (English/Spanish/TTY)
Postal Mail	Puerto Rico Department of Housing CDBG-DR Internal Audit Office P.O. BOX 21355 San Juan, PR 00928-1355
Email	hotlineCDBG@vivienda.pr.gov
Internet	www.cdbg-dr.pr.gov https://cdbg-dr.pr.gov/app/cdbgdrpublic/Fraud
In person	Request a meeting with the Deputy Audit Director of the CDBG-DR Internal Audit Office located at PRDOH's

	Headquarters at 606 Barbosa Avenue, Building Juan C. Cordero Dávila, Río Piedras, PR 00918.

REPORT FRAUD, WASTE, ABUSE, OR MISMANAGEMENT DIRECTLY TO HUD OIG	
HUD OIG Hotline	1-800-347-3735 (Toll-Free) 787-766-5868 (Spanish)
Postal Mail	HUD Office of Inspector General (OIG) Hotline 451 7th Street SW Washington, D.C. 20410
Email	HOTLINE@hudoig.gov
Internet	https://www.hudoig.gov/hotline

The AFWAM Policy and all CDBG-DR Program policies are posted in English and Spanish at https://www.cdbg-dr.pr.gov/en/resources/policies/general-policies/ and https://www.cdbg-dr.pr.gov/recursos/politicas/politicas-generales/.

CERTIFICATIONS

CERTIFICATIONS

PRDOH acknowledges HUD guidance at 48 FR 45838, 45869 which wives 24 C.F.R. 91.225 and 91.325 and requires each grantee receiving a direct allocation of CDBG– MIT funds to make the following certifications with its action plan:

a) PRDOH certifies that it has in effect and is following a residential anti-displacement and relocation assistance plan in connection with any activity assisted with funding under the CDBG-MIT Program.
b) PRDOH certifies its compliance with restrictions on lobbying required by 24 C.F.R. part 87, together with disclosure forms, if required by part 87.
c) PRDOH certifies that the Action Plan is authorized under state and local law (as applicable) and that the grantee, and any entity or entities designated by the grantee, and any contractor, subrecipient, or designated public agency carrying out an activity with CDBG–MIT funds, possess (es) the legal authority to carry out the program for which it is seeking funding, in accordance with applicable HUD regulations and Federal Register Vol. 84, No. 169 (August 30, 2019), 84 FR 45838. The grantee certifies that activities to be undertaken with CDBG–MIT funds are consistent with its Action Plan.
d) PRDOH certifies that it will comply with the acquisition and relocation requirements of the URA, as amended, and implementing regulations at 49 C.F.R. part 24, except where waivers or alternative requirements are provided for CDBG-MIT funds.
e) PRDOH certifies that it will comply with section 3 of the Housing and Urban Development Act of 1968 (12 U.S.C. 1701u), and implementing regulations at 24 C.F.R. part 135.
f) PRDOH certifies that it is following a detailed citizen participation plan that satisfies the requirements of 24 C.F.R. 91.105 or 91.115 (except as provided for in notices providing waivers and alternative requirements for this grant). Also, each local government receiving assistance from a State grantee must follow a detailed citizen participation plan that satisfies the requirements of 24 C.F.R. 570.486 (except as provided for in notices providing waivers and alternative requirements for this grant).
g) PRDOH certifies that it has consulted with affected local governments in counties designated in covered major disaster declarations in the non-entitlement, entitlement, and tribal areas of the State in determining the uses of funds, including method of distribution of funding, or activities carried out directly by the State.
h) PRDOH certifies that it is complying with each of the following criteria:
    (1) Funds will be used solely for necessary expenses related to mitigation activities, as applicable, in the most impacted and distressed areas for which the President declared a major disaster in 2015, 2016, or 2017 pursuant to the Robert T. Stafford Disaster Relief and emergency Assistance Act of 1974 (42 U.S.C. 5121 et seq.).

(2) With respect to activities expected to be assisted with CDBG-MIT funds, the Action Plan has been developed to give priority to activities that will benefit LMI families.

(3) The aggregate use of CDBG-MIT funds shall principally benefit low- and moderate-income families in a manner that ensures that at least fifty percent (50%) (or another percentage permitted by HUD in a waiver published in an applicable Federal Register notice) of the grant amount is expended for activities that benefit such persons.

(4) PRDOH will not attempt to recover any capital costs of public improvements assisted with CDBG-MIT funds, by assessing any amount against properties owned and occupied by persons of low- and moderate-income, including any fee charged or assessment made as a condition of obtaining access to such public improvements, unless: (a) CDBG-MIT funds are used to pay the proportion of such fee or assessment that relates to the capital costs of such public improvements that are financed from revenue sources other than under this title; or (b) for purposes of assessing any amount against properties owned and occupied by persons of moderate income, PRDOH certifies to the Secretary that it lacks sufficient CDBG funds (in any form) to comply with the requirements of clause (a).

i) PRDOH certifies that the grant will conducted and administered in conformity with title VI of the Civil Rights Act of 1964 (42 U.S.C. 2000d) and the Fair Housing Act (42 U.S.C. 3601–3619) and implementing regulations, and that it will affirmatively further fair housing.

j) PRDOH certifies that it has adopted and is enforcing the following policies, and, in addition, must certify that they will require local governments that receive grant funds to certify that they have adopted and are enforcing:

(1) A policy prohibiting the use of excessive force by law enforcement agencies within its jurisdiction against any individuals engaged in nonviolent civil rights demonstrations; and

(2) A policy of enforcing applicable State and local laws against physically barring entrance to or exit from a facility or location that is the subject of such nonviolent civil rights demonstrations within its jurisdiction.

k) PRDOH certifies that it (and any subrecipient or administering entity) currently has or will develop and maintain the capacity to carry out mitigation activities, as applicable, in a timely manner and that PRDOH has reviewed the requirements of 84 FR 45838. PRDOH certifies to the accuracy of its Public Law 115-123 Financial Management and Grant Compliance certification checklist, or other recent certification submission, if approved by HUD, and related supporting documentation referenced at V.A.1.a of 84 FR 45838 and its Implementation Plan and Capacity Assessment and related submissions to HUD referenced at V.A.1.b.

l) PRDOH certifies that it considered the following resources in the preparation of its action plan, as appropriate: FEMA Local Mitigation Planning Handbook: https://www.fema.gov/media-library-data/1590070172371-48e87ca446838ba81afc2aca995940bc/FEMA_Local_Mitigation_Planning_Handb ook_508.pdf; DHS Office of Infrastructure Protection: https://www.cisa.gov/sites/default/files/publications/ip-fact-sheet-508.pdf; National Association of Counties, Improving Lifelines (2014): https://www.naco.org/sites/default/files/documents/NACo_ResilientCounties_Lifelines_Nov2014.pdf; the National Interagency Coordination Center (NICC) for coordinating the mobilization of resources for wildland fire: www.nifc.gov/nicc/); the U.S. Forest Service's resources around wildland fire (https://www.fs.fed.us/managing-land/fire); and HUD's CPD Mapping tool: https://egis.hud.gov/cpdmaps/.

m) PRDOH certifies it will not use CDBG-MIT funds for any activity in an area identified as flood prone for land use or hazard mitigation planning purposes by the State, or local government or delineated as a special flood hazard area (or 100-year floodplain) in FEMA's most recent flood advisory maps, unless it also ensures that the action is designed or modified to minimize harm to or within the floodplain, in accordance with Executive Order 11988 and 24 C.F.R. part 55. The relevant data source for this provision is the State, and local government land use regulations and hazard mitigation plan and the latest issued FEMA data or guidance, which includes advisory data (such as Advisory Base Flood Elevations) or preliminary and final Flood Insurance Rate Maps.
n) PRDOH certifies that its activities concerning lead-based paint will comply with the requirements of 24 C.F.R. part 35, subparts A, B, J, K, and R.
o) PRDOH certifies that it will comply with environmental requirements at 24 C.F.R. Part 58.
p) PRDOH certifies that it will comply with applicable laws.

Warning: Any person who knowingly makes a false claim or statement to HUD may be subject to civil or criminal penalties under 18 U.S.C. 287, 1001 and 31 U.S.C. 3729.

Signature

THIS IS THE DRAFT FOR PUBLIC COMMENT- NO SIGNATURE REQUIRED

Luis Carlos Fernández- Trinchet
Secretary, PRDOH

APPENDICES

PUERTO RICO

MITIGATION ACTION PLAN

Community Development Block Grant - Mitigation *(CDBG-MIT)*