2021

PUERTO RICO
STATE NATURAL HAZARD MITIGATION PLAN

DEPARTAMENTO DE SEGURIDAD PÚBLICA
CENTRAL OFFICE FOR RECOVERY, RECONSTRUCTION AND RESILIENCY
COR3
P3 AAFAF

2021 PUERTO RICO STATE NATURAL HAZARDS MITIGATION PLAN

PUERTO RICO DEPARTMENT OF PUBLIC SAFETY
Alexis Torres Rios
Secretary

PUERTO RICO EMERGENCY MANAGEMENT BUREAU
Nino Correa Filomeno
Interim Commissioner

PUERTO RICO CENTRAL OFFICE FOR RECOVERY, RECONSTRUCTION AND RESILIENCY
Manuel A. Laboy Rivera
Executive Director and Governor's Authorized Representative (GAR)

STATE HAZARD MITIGATION OFFICER
Ivelysse Lebrón Durand

This Plan has been prepared by the Puerto Rico Emergency Management Bureau (NMEAD) in collaboration with the Central Office of Recovery, Reconstruction and Resilience of Puerto Rico (COR3) and the Graduate School of Planning of the University of Puerto Rico (UPR)

APPROVED BY THE FEDERAL EMERGENCY MANAGEMENT AGENCY
July 30, 2021

GOBIERNO DE PUERTO RICO
LA FORTALEZA
SAN JUAN, PUERTO RICO

Boletín Administrativo Núm. OE-2021-059

ORDEN EJECUTIVA DEL GOBERNADOR DE PUERTO RICO, HON. PEDRO R. PIERLUISI, PARA ADOPTAR EL PLAN ESTATAL DE MITIGACIÓN DE RIESGOS NATURALES DE PUERTO RICO, ORDENAR SU IMPLEMENTACIÓN Y PARA DEROGAR EL BOLETÍN ADMINISTRATIVO NÚM. OE-2016-021

POR CUANTO: Nuestra Administración está comprometida con salvaguardar el orden público, proteger la vida, la seguridad y la salud de nuestros ciudadanos.

POR CUANTO: La Ley Núm. 20-2017, según enmendada, conocida como la "Ley del Departamento de Seguridad Pública de Puerto Rico", ("Ley Núm. 20") estableció la política pública del Gobierno de Puerto Rico para atender situaciones de emergencia o desastre, así como proveer asistencia necesaria y efectiva para la protección antes, durante y después de estos eventos. Para ello, el Secretario de Seguridad Pública es el funcionario con el deber y la facultad para desarrollar e implementar los Planes de Estado, incluyendo el Plan Anti-Crimen, el Plan de Desastres Naturales, el Plan de Catástrofes, Plan de Continuidad de Operaciones, Plan de Mitigación y cualquier otro plan que sea requerido por reglamentaciones estatales y federales. Ver Artículo 1.05 (t) de la Ley Núm. 20.

POR CUANTO: Para que el Gobierno de Puerto Rico sea elegible para solicitar asistencia para desastres, incluyendo subvenciones para la mitigación de riesgo, es imprescindible el cumplimiento con los requisitos de la Sección 322 del "Robert T. Stafford Disaster Relief and Emergency Assistance Act", 42 USC. 5165, promulgada en virtud de la Sección 104 de la "Disaster Mitigation Act of 2000", Ley Pública Núm. 106-390 del 30 de octubre de 2000.

POR CUANTO: La reglamentación federal aplicable requiere que el Plan Estatal de Mitigación de Riesgos Naturales sea adoptado formalmente por el Estado antes de someterlo a la Administración Federal para el Manejo de Emergencias ("FEMA", por sus siglas en inglés) para el proceso de revisión y aprobación final. Ver 44 C.F.R. § 201.4(c)(6).

POR TANTO: Yo, PEDRO R. PIERLUISI, Gobernador de Puerto Rico, en virtud de los poderes inherentes a mi cargo y la autoridad que me ha sido conferida por la Constitución y las leyes del Gobierno de Puerto Rico, por la presente, decreto y ordeno lo siguiente:

SECCIÓN 1ª: **PLAN ESTATAL DE MITIGACIÓN DE RIESGOS NATURALES DE PUERTO RICO.** Se adopta el "Plan Estatal de Mitigación de Riesgos Naturales de Puerto Rico" ("PEMRN-2021") como el plan de mitigación oficial del Gobierno de Puerto Rico.

SECCIÓN 2ª: **COMITÉ INTERAGENCIAL PARA LA MITIGACIÓN DE RIESGOS NATURALES Y TECNOLÓGICOS.** El Comité Interagencial para la Mitigación de Riesgos Naturales y Tecnológicos, así como las entidades gubernamentales identificadas en el PEMRN-2021, implementarán las acciones de mitigación allí señaladas y presentarán informes trimestrales sobre el progreso y cumplimiento de las referidas actividades al Gobernador y al Secretario del Departamento de Seguridad Pública.

SECCIÓN 3ª: **INFORME ANUAL.** El Comité Interagencial para la Mitigación de Riesgos Naturales y Tecnológicos rendirá al Gobernador un informe anual sobre la ejecución del PEMRN-2021. Este informe será presentado en o antes del treinta (30) de abril de cada año.

SECCIÓN 4ª: **DEROGACIÓN.** Esta Orden Ejecutiva deja sin efecto el Boletín Administrativo Núm. OE 2016-021 y cualquier otra orden ejecutiva que en todo o en parte sea incompatible con ésta hasta donde existiera tal incompatibilidad.

SECCIÓN 5ª: **VIGENCIA.** Esta Orden Ejecutiva entrará en vigor inmediatamente y se mantendrá vigente hasta que sea enmendada o revocada por una Orden Ejecutiva posterior o por operación de ley.

SECCIÓN 6ª: **NO CREACIÓN DE DERECHOS EXIGIBLES.** Esta Orden Ejecutiva no tiene como propósito crear derechos sustantivos o procesales a favor de terceros, exigibles ante foros judiciales, administrativos o de cualquier otra índole, contra el Gobierno de Puerto Rico o sus agencias, sus oficiales, empleados o cualquiera otra persona.

SECCIÓN 7ª: **SEPARABILIDAD.** Las disposiciones de esta Orden Ejecutiva son independientes y separadas unas de otra. Si un tribunal con jurisdicción y competencia declarase inconstitucional, nula o inválida cualquier parte, sección, disposición u oración de esta Orden Ejecutiva, la determinación a tales efectos no afectará la validez de las disposiciones restantes, las cuales permanecerán en pleno vigor.

SECCIÓN 8ª: **PUBLICACIÓN.** Esta Orden Ejecutiva debe ser presentada inmediatamente en el Departamento de Estado y se ordena su más amplia publicación.

EN TESTIMONIO DE LO CUAL, expido la presente Orden Ejecutiva bajo mi firma y hago estampar el gran sello del Gobierno de Puerto Rico, en La Fortaleza, en San Juan, Puerto Rico, hoy 29 de julio de 2021.

PEDRO R. PIERLUISI
GOBERNADOR

Promulgada de conformidad con la ley, hoy 29 de julio de 2021.

OMAR J. MARRERO DÍAZ
SECRETARIO DE ESTADO

U.S. Department of Homeland Security
Region II
Jacob K. Javits Federal Office Building
26 Federal Plaza, Room 1311
New York, New York 10278-0002

FEMA

July 30, 2021

The Honorable Pedro R. Pierluisi Urrutia
Governor
Government of Puerto Rico
Office of the Governor
Post Office Box 9020082
San Juan, Puerto Rico 00902-0082

Reference: Approval of the 2021 Puerto Rico State Hazard Mitigation Plan

Dear Governor Pierluisi:

The U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA) Region II Mitigation Division, Risk Analysis Branch has approved the 2021 Puerto Rico State Hazard Mitigation Plan effective July 30, 2021 through July 29, 2026 in accordance with the planning requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended, the National Flood Insurance Act of 1968, as amended, and Title 44 Code of Federal Regulations (CFR) Part 201.

A FEMA-approved state mitigation plan is a condition of receiving certain non-emergency Stafford Act assistance and FEMA hazard mitigation assistance grants from the following programs:

- Public Assistance Categories C–G (PA C–G) and 406
- Fire Management Assistance Grants (FMAG)
- Hazard Mitigation Grant Program (HMGP)
- Building Resilient Infrastructure and Communities (BRIC)
- Flood Mitigation Assistance (FMA)
- High Hazard Potential Dams (HHPD)

State hazard mitigation plans must be regularly updated and submitted to FEMA Region II Mitigation Division, Risk Analysis Branch for review and approval. If the plan is not updated and approved by the date indicated in this FEMA approval letter the plan is considered lapsed and FEMA can not obligate funds until the mitigation plan is approved by FEMA.

If at any time over the plan approval period FEMA determines that the state is not complying with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives funding or is unable to fulfill mitigation commitments, FEMA may take action to correct the noncompliance (44 CFR § 201.3(b)(5) and 201.4(c)(7)).

In addition, FEMA will provide a reminder to the state, at a minimum, 12 months prior to the plan expiration date, of the consequences of not having a FEMA-approved mitigation plan with respect to eligibility for the FEMA assistance programs that require a FEMA-approved mitigation plan as a condition of eligibility. To maintain eligibility for PA C–G and 406, FMAG, HMGP, BRIC, FMA, and HHPD the state must submit a draft of the next plan update prior to the end of the approval period, and allow sufficient time for the review and approval process, including any revisions, if needed, and for the formal adoption by the state following determination by FEMA that the plan has achieved a status of "Approvable Pending Adoption."

Finally, we look forward to working with you to discuss the status of the state mitigation program each year over the approval period. The written consultation agreement is attached to clarify expectations regarding the consultation progress, including details such as purpose and outcomes, points of contact, roles and responsibilities, and logistics.

If we can be of assistance, please contact Michael Foley at (347) 610-1847, or Michael.foley3@fema.dhs.gov.

Sincerely,

Michael F. Moriarty
Director, Mitigation Division

Attachments:

1. State Mitigation Plan Review Tool
2. Mitigation Program Consultation Agreement

NÚMERO: 2021-000038

GOBIERNO DE PUERTO RICO
DEPARTAMENTO DE SEGURIDAD PÚBLICA
NEGOCIADO PARA EL MANEJO DE EMERGENCIAS Y
ADMINISTRACIÓN DE DESASTRES

ACUERDO DE COLABORACIÓN

-----**De la Primera Parte:** El **Departamento de Seguridad Pública** representado en este acto por su Secretario Designado, Alexis Torres Ríos, mayor de edad, casado y vecino de San Juan, Puerto Rico y/o por su Secretario Auxiliar de Gerencia y Administración, José Luis Jiménez Domenech, mayor de edad, soltero y vecino de San Juan, Puerto Rico, autorizado a firmar en virtud de la Orden Administrativa DSP-2021-A-001 del 23 de febrero de 2021, y el **Negociado para el Manejo de Emergencias y Administración de Desastres,** representados en este acto por su Comisionado Interino, Nino Correa Filomeno, casado, mayor de edad y vecino de Carolina, Puerto Rico. Ambas entidades creadas al amparo de la Ley 20-2017, según enmendada, conocida como *"Ley del Departamento de Seguridad Pública de Puerto Rico"*; y cuyas facultades legales y autoridad representativa para el presente acto se desprende de los Artículos 1.05 y 5.05 (d) respectivamente, de la Ley Núm. 20, antes citada, en adelante denominados en este acuerdo como NMEAD. ---

-----**De la Segunda Parte:** El **Recinto de Río Piedras de la Universidad de Puerto Rico**, en adelante **UPR-RP**, representada en este acto por su Rector, el Dr. Luis A. Ferrao Delgado, mayor de edad, casado, y vecino de San Juan, Puerto Rico, cuyas facultades para comparecer en este acto surgen de la Ley Número 1 del 20 de enero de 1966, según enmendada, conocida como la *Ley de la Universidad de Puerto Rico*. ----------------------------

-----Por el presente Acuerdo de Colaboración el NMEAD y la **UPR-RP** establecen los lineamientos que dirigirán los servicios que la **UPR-RP** habrá de prestar al NMEAD a través de su Escuela Graduada de Planificación (**EGP**) para apoyar la actualización del Plan Estatal de Mitigación de Peligros Riesgos Naturales de Puerto Rico del 2016, (en adelante, el PEMPN). ---

---**EXPOSICIÓN**--

-----**Primero**: El PEMPN responde al mandato de la ley federal *Disaster Mitigation Act* del año 2000 (DMA 2000). La DMA 2000, provee las bases legales para que la Agencia

Federal de Manejo de Emergencias (FEMA, por sus siglas en inglés) defina y establezca los requisitos y condiciones, al gobierno Estatal y Local (municipal), para recibir ayuda financiera federal para mitigar los daños que puedan causar los peligros naturales. Puerto Rico ha cumplido efectivamente con los requisitos de esta Ley desde su inicio, y el PEMPN tiene una vigencia de cinco (5) años, cuya versión vigente tiene como fecha de expiración el 18 de agosto de 2021. A raíz de la Declaración Presidencial de Desastre provocada por el huracán María, el NMEAD tiene la facultad en Ley de liderar la coordinación de la actualización del PEMPN. ---

-----**Segundo:** La responsabilidad de la actualización del PEMPN recae sobre el Director de Mitigación del NMEAD. Entre las tareas que realiza la oficina de Mitigación del NMEAD relacionadas a la actualización del PEMPN son las siguientes: (1) Análisis de datos e identificación de metodologia para identificar riesgos y vulnerabilidad; (2) Análisis de los activos en el territorio conforme al fenómeno atmosférico; (3) Conocimiento en la interconectividad de los sistemas, especialmente en la infraestructura crítica; (4) Capacidad de priorización en asistencia técnica y financiera para el análisis de riesgos y la implantación de acciones de mitigación; (5) Desarrollo de mecanismos para monitoreo, evaluación, actualización y priorización; (6) Programación (definición de la temporalidad, financiamiento, análisis de costo-efectividad) y redacción de narrativa de las metodologías aplicadas, según el itinerario de trabajo del PEMPN. (Anejo 1) ------------------------------------

-----**Tercero:** Por primera vez, la actualización del PEMPN 2021 contará con la contribución y el apoyo de la academia. Esta responsabilidad recae en la Escuela Graduada de Planificación de la Universidad de Puerto Rico (EGP) por su experiencia técnica y científica en las áreas de riesgo de mitigación y desarrollo de planes, según se desprende del Plan de Trabajo realizado a tales fines. (Anejo 2) --

-----**Cuarto:** El propósito fundamental de esta colaboración es colocar los cimientos de una plataforma académica-investigativa para atender esa necesidad de planificación de mitigación de riesgos. Para ello el UPR-RP realizará la evaluación de riesgos a nivel Isla y desarrollo de estrategias de mitigación revisando y unificando los datos relacionados a los siguientes riesgos: vientos fuertes, inundaciones, deslizamientos, sequia, terremoto, y fallas geológicas. ---

-----Se realizará un perfil de riesgos para toda la isla, el cual identificará recomendaciones y acciones de planificación a realizar referente a los seis riesgos que forman parte del Plan: viento severo, inundaciones (costeras y rivereñas), terremoto, sequía, fisura geológica y derrumbe. Esta información estará acompañada de mapas, datos, imágenes y tablas en formatos editables que formen parte de los análisis realizados. --------------------------------------

-----**Quinto**: La EGP desarrolló el curso a nivel graduado titulado Riesgos Naturales/Antropogénicos y Planificación, el cual se ofrece en el Primer Semestre Académico 2020-2021. (Anejo 3). Entre los objetivos del curso se encuentra el enfatizar sobre el análisis multirriesgo y sus implicaciones en el proceso de planificación; analizar de manera comprensiva el impacto físico y social que estos eventos producen sobre el ordenamiento territorial y la vulnerabilidad sobre las comunidades; enfatizar en el instrumento de identificación del perfil de riesgos con el propósito de delimitar planes y protocolos de protección exitosos ante estos eventos; integrar los análisis realizados al PEMPN. ---

-----**Sexto:** Los estudiantes de la EGP cuentan con un dominio excelente de estas materias además de una formación en planificación urbana, ambiental y económica lo que les provee un marco teórico para aportar en la actualización del PEMPN que lleva a cabo el NMEAD. ---

-----**Séptimo**: Es interés del NMEAD contar con la colaboración de la EGP para que los estudiantes adquieran destrezas en el área de planificación, mitigación y manejo de riesgos naturales y antropogénicos, una materia especializada como la que se practica en el NMEAD. Además, los estudiantes, a través de su participación obtendrán una sólida experiencia de práctica con carga académica mientras continúan sus estudios de maestría. Del mismo modo, el NMEAD beneficiaría al tener estudiantes altamente cualificados que ayudarían a adelantar los estudios de los riesgos/peligros naturales y antropogénicos que presencian las áreas geográficas de Puerto Rico. ---

-----La participación indirecta de los estudiantes a través del curso estará bajo la supervisión de la facultad a cargo del curso en cuestión. Los profesores trabajaran en coordinación con personal del NMEAD para asegurar que se cumpla con los requisitos mínimos establecidos en las guías para la elaboración del Plan (State Mitigation Plan Review Guide FEMA 2015). ---

-----**Octavo:** El UPR-RP colaborará, junto al Director de Mitigación del NMEAD en la revisión de listas, bases de datos, información, mapas de riesgos, entre otros documentos, a diversas escalas relativos al proyecto; redactar y presentar informes y recomendaciones de los trabajos realizados; y llevar a cabo otras tareas relacionadas que se le asignen, siempre con el acompañamiento y en coordinación con el NMEAD. Para esto se realizarán reuniones semanales, incluyendo intercambio de correos electrónicos y llamadas telefónicas para que la EGP informe sobre el progreso de los trabajos. -------------------------

-----**Noveno:** Toda información recopilada por los estudiantes durante sus trabajos, así como documentos, materiales y equipos que se le provean, serán propiedad de la RRP-EGP como parte de la generación de conocimiento que forma parte de su misión educativa. Los mismos podrán publicarse, presentarse o transferirse a terceras personas naturales o jurídicas para fines académicos u otros fines solicitados por NMEAD, solamente mediante autorización escrita de la UPR-RP. Esta información será provista por EGP al NMEAD en formato Word, así como mapas y datos georreferenciados en formatos editables. El NEMAD le proveerá a la EGP datos disponibles en formatos editables, así como guías de trabajo, estimados de daños reportados y material de referencia. El NMEAD cooperará y facilitará el desarrollo del perfil de riesgos de la EGP coordinando y facilitando la interacción con sus recursos técnicos y peritaje disponible para facilitar. Cada una de las partes, será responsable de sus costos y asume total responsabilidad por sus actos y producto de su trabajo. --

-----**Décimo:** Este esfuerzo no conlleva intercambio económico entre las partes. ---------------

-----**Undécimo:** AMBAS PARTES se comprometen a conservar los informes, hojas de trabajo y asistencia y demás documentos relacionados con los servicios, objeto de este Acuerdo, para que puedan ser examinados o copiados por la Oficina de Auditores Internos de la Universidad de Puerto Rico, por una firma de auditores externos contratados por la Universidad de Puerto Rico o por la Oficina del Contralor de Puerto Rico, en sus intervenciones al UPR-RP. Las auditorías se realizarán en fechas razonables durante el transcurso de los servicios o con posterioridad a los mismos, conforme las prácticas de auditoría generalmente reconocidas. Dichos documentos se conservarán por un período no menor de seis (6) años o hasta que se efectúe una investigación por la Oficina del Contralor de Puerto Rico, lo que ocurra primero. ---

-----**Duodécimo:** Ambas PARTES hacen constar que no habrá discrimen por razones de raza, color, sexo, nacimiento, edad, origen o condición social, ascendencia, estado civil, ideas o creencias religiosas o políticas, género, orientación sexual, nacionalidad, origen étnico, condición de veterano de las Fuerzas Armadas o incapacidad física o mental en las prácticas de empleo, contratación y subcontratación. ---

-----**Decimotercera: DE CUMPLIMIENTO CON LA LEY ORGÁNICA DE LA OFICINA DE ÉTICA GUBERNAMENTAL**: Ambas PARTES hacen constar que ningún empleado o funcionario de sus respectivas instituciones o agencias tiene interés pecuniario, directo o indirecto, en la otorgación de este contrato a tenor con la Ley 1-2012, según enmendada, conocida como la *Ley Orgánica de la Oficina de Ètica Gubernamental.* De igual manera, el funcionario que representa al UPR-RP y al NMEAD en este acto no tiene ningún tipo de interés pecuniario en la realización de éste. Asimismo, ambas partes acuerdan cumplir con todas las disposiciones de la Ley Núm. 2-2018, conocida como el *Código Anticorrupción para el Nuevo Puerto Rico* y aceptan que actuarán de acuerdo con los estándares éticos de su profesión y, bajo estos, ambas partes asumen la responsabilidad de sus acciones. -------

-----**Decimocuarta:** Ambas PARTES se comprometen a observar y cumplir con las disposiciones de la Ley Federal "*Family Educational Rights and Privacy ACT of 1974*" (Buckley Amendment) en lo referente a la no divulgación de expedientes o de información confidencial de estudiantes de la **SEGUNDA PARTE.** ---

-----**Decimoquinta: DE CANCELACIÓN O RESOLUCIÓN:** Las PARTES podrán terminar el contrato mediante notificación con treinta (30) días de antelación a la fecha de resolución. Además, las PARTES podrán cancelar el contrato de forma inmediata sin previo aviso cuando la parte contratada incurra en negligencia, incumplimiento o violación de alguna condición del contrato. Este contrato podrá ser rescindido si durante su ejecución alguna de las PARTES resulta culpable por delitos contra el erario, la fe y la función pública o que envuelvan fondos o propiedad pública estatal o federal. -----------------

-----**Decimosexta:** Ninguna PARTE utilizará el nombre de la otra PARTE, las de sus siglas, iniciales distintivas, sellos, logos, escudo o cualquier marca distintiva de este, en ningún medio impreso o electrónico existente o futuro, sin que medie la autorización previa, expresa de la OTRA. ---

-----**Decimoséptima:** Ninguna prestación o contraprestación objeto de este contrato podrá exigirse hasta tanto el mismo se haya presentado para registro en la Oficina del Contralor a tenor con lo dispuesto en la Ley Núm. 18 de 30 de octubre de 1975, según enmendada. ----

-----**Decimoctava:** Este Acuerdo estará regido y deberá ser interpretado a tenor con las leyes del Estado Libre Asociado de Puerto Rico, y cualquier causa de acción que surja de éste sólo podrá ser incoada en los tribunales del Estado Libre Asociado de Puerto Rico. ----

-----**Decimonovena**: Este Acuerdo de Colaboración constituye el único acuerdo entre las partes. Ahora bien, las PARTES estipulan que cualquier enmienda, cambio o modificación que las partes acuerden con respecto a los términos y condiciones del presente Acuerdo deberá incorporarse al mismo mediante enmienda escrita. --

-----**Vigésima**: **VIGENCIA**: Su vigencia comienza cuando ambas partes hayan suscrito el mismo y estará vigente hasta el 31 de diciembre de 2021. ---

-----**Vigesimoprimera: CLÁUSULA DE LIBERACIÓN:** La UPR-RP será responsable de cualquier reclamación judicial y/o extrajudicial y/o administrativa y de proveer indemnización por concepto de daños y perjuicios y/o angustias mentales o morales que pueda sufrir o alegue sufrir, cualquier persona natural o jurídica, donde los daños y perjuicios aleguen haber sido causados por acciones, actuaciones u omisiones negligentes, descuidadas y/o culposas de la UPR-RP, sus agentes, empleados o personas por las que deba responder, cuando tales daños hubieren ocurrido total o parcialmente durante la ejecución del presente Acuerdo. De igual forma, la NMEAD será responsable de cualquier reclamación judicial y/o extrajudicial y/o administrativa y de proveer indemnización por concepto de daños y perjuicios y/o angustias mentales o morales que pueda sufrir o alegue sufrir, cualquier persona natural o jurídica, donde los daños y perjuicios aleguen haber sido causados por acciones, actuaciones u omisiones negligentes, descuidadas y/o culposas de la NMEAD, sus agentes, empleados o personas por las que deba responder, cuando tales daños hubieren ocurrido total o parcialmente durante la ejecución del presente Acuerdo, eximiendo, relevando y exonerando al UPR-RP de toda responsabilidad. ------------------------

-----**Vigesimosegunda**: Cualquier comunicación relacionada con este Acuerdo será referido, por escrito o por correo electrónico, con acuse de recibo a la parte interesada conforme aquí se expresa:

Cuando el destinatario sea la UPR, dirigida a:

Nombre del funcionario: Dra. Norma Peña
Oficina: Escuela Graduada de Planificación
Dirección postal: 10 Ave. Universidad STE 1001
San Juan, Puerto Rico 00925-2530
Correo electrónico: norma.pena1@upr.edu
Teléfono: 787-764-0000

Cuando el destinatario sea el NMEAD, dirigida a:

Nombre del funcionario: Nino Correa Filomeno
Oficina: Oficina del Comisionado
Dirección postal: Carr. 1, Km 24.5
Quebrada Arenas
San Juan, PR 00926
Correo electrónico: earroyo@prema.pr.gov
Teléfono: 787-724-0124

-----**Vigesimotercera**: **CLÁUSULA DE SEPARABILIDAD**: Si cualquier Tribunal Estatal o Federal declara que alguna Cláusula de este Acuerdo es inconstitucional o ilegal, las demás Cláusulas permanecerán inalteradas y en toda su fuerza y vigor. ------------------------

-----**Vigesimocuarta:** Las PARTES manifiestan que la firma de este Acuerdo y los compromisos contraídos en el mismo, son producto de su buena fe, por lo que realizarán todas las acciones necesarias para su debido cumplimiento; en caso de presentarse alguna discrepancia sobre su interpretación, ésta será resuelta de común acuerdo por las partes en el espíritu que las animó a suscribirlo. ---

-----**Vigesimoquinta: DE CONFLICTO DE INTERESES: LAS PARTES** reconocen que en el descargo de sus obligaciones en este Acuerdo tiene un deber de lealtad UNA hacia la OTRA, lo que incluye el no tener intereses adversos. Representa intereses en conflicto cuando su conducta es descrita como tal en las normas éticas reconocidas en las leyes y reglamentos del Gobierno de Puerto Rico. Se evitará aún la apariencia de la existencia de intereses encontrados. Por cuanto, AMBAS PARTES afirman no mantener algún contrato o relaciones de negocio que les pueda generar un conflicto de intereses o la apariencia del mismo. ---

-----**Vigesimosexta: CLÁUSULA DE CONTRATISTA INDEPENDIENTE**: Las PARTES estipulan que todos los servicios bajo este contrato se rinden en el carácter de contratista independiente. Reconocen, además, que este contrato no concede a sus empleados u agentes los derechos y prerrogativas que las leyes y reglamentos aplicables proveen para los empleados regulares de la UPR-RP o del NMEAD. --

-----**Vigesimoséptima: CLÁUSULA CUMPLIMIENTO DE LEYES Y SELECCIÓN DE FORO:** Las PARTES serán responsables del fiel cumplimiento de todos los reglamentos y leyes del Estado Libre Asociado de Puerto Rico y de los Estados Unidos de América, según apliquen, así como de la Ley de la Universidad de Puerto Rico y de sus reglamentos. Además, las PARTES estipulan y aceptan que este contrato se regirá e interpretará de acuerdo con las leyes del Estado Libre Asociado de Puerto Rico y que el tribunal con jurisdicción para cualquier reclamo relacionado con la ejecución de este contrato lo será la sección correspondiente del Tribunal General de Justicia, Tribunal de Primera Instancia, Sala de San Juan. --

-----**Vigesimoctava: PROTECCIÓN INFORMACIÓN PERSONAL:** Las PARTES manifiestan que cumplirán y se obligan de forma expresa a cumplir con las sobre protección de datos de carácter personal, comprometiéndose a dar un uso debido a los datos de tal naturaleza que obtengan como consecuencia del desarrollo del presente Acuerdo. ---

-----**Vigesimonovena: PROPIEDAD INTELECTUAL:** LAS PARTES estipulan que lo relativo a propiedad intelectual que surja como resultado de la actividad conjunta de las partes en el presente Acuerdo, se establecerá conforme a lo establecido en la reglamentación que regula estos aspectos las leyes vigentes. Cuando se trate de un trabajo conjunto, las PARTES siempre compartirán la titularidad. En todo momento se reconocerá a los creadores su derecho de firmar como autores en todos aquellos documentos que legalmente corresponda. Respecto de los Proyectos de Investigación, cada una de las partes se compromete a no difundir, bajo ningún aspecto, las informaciones científicas o técnicas en el desarrollo de los proyectos de investigación que se lleven a cabo. Cuando una de las partes desee utilizar los resultados parciales o finales, en parte o en su totalidad, deberá solicitar la conformidad de la otra parte. Las publicaciones relativas a trabajos de investigación conjuntas dentro de este Acuerdo deberán ser aprobadas por los organismos correspondientes a cada institución y deberán mencionar que el trabajo se realizó como resultado del presente Acuerdo. Cualquiera que sea el modo de difusión, se respetará siempre la mención de los/las autores/as del trabajo, figurando los nombres de ambas partes como de los terceros que participen en calidad de inventores/as. --

--**Aceptación y Firma**--

-----Las PARTES, manifiestan luego de leer, revisar y entender todo el contenido de este acuerdo y así lo aceptan por encontrar que el mismo está redactado a su entera satisfacción y que establece fielmente lo pactado, y para que así conste suscriben el presente Acuerdo. --

-----**PARA QUE ASI CONSTE**, las **PARTES** suscriben el presente **ACUERDO**, con su firma e iniciales al margen izquierdo de cada una de sus páginas, dado en San Juan, Puerto Rico. ---

Alexis Torres Ríos
Secretario Designado
Departamento de Seguridad Pública
235 Ave. Arterial Hostos
Edif. Capital Center, Torre Norte
San Juan, PR 00918
SSP: 66-0896409

FECHA: ____________

Luis A. Ferrao Delgado
Rector
Recinto Rio Piedras
Universidad de Puerto Rico
2534 Ave. Universidad
San Juan, PR 00925
SSP: 66-0433760

FECHA: 29/APR/2021

José Luis Jiménez Domenech
Secretario Auxiliar de Gerencia y Administración
Departamento de Seguridad Pública
SSP: 66-0896409

FECHA: 29/APR/2021

Nino Correa Filomeno
Comisionado Interino
NMEAD
Carr. 1, Km 24.5
Quebrada Arenas
San Juan, PR 00926
SSP: 66-0637472

FECHA: 29/APR/2021

El Plan de Mitigación

El Negociado para el Manejo de Emergencias y Administración de Desastres (NMEAD), es parte del Departamento de Seguridad Pública (DSP), conforme establece la Ley Núm. 20 del 10 abril de 2017, conocida como "Ley del Departamento de Seguridad Pública de Puerto Rico (DSP)". Bajo las disposiciones de esta Ley, así como las disposiciones de las Órdenes Ejecutivas 2014-043 y 2014-044, le corresponde al NMEAD la responsabilidad de la Preparación, Mitigación, Respuesta y Recuperación antes, durante y después de cualquier incidente o evento de emergencia.

Parte esencial de las múltiples responsabilidades del NMEAD es desarrollar y mantener los Planes de Emergencia de Puerto Rico. Entre los planes que el NMEAD desarrolla y mantiene está el Plan de Mitigación Estatal, el cual es requerido por "Robert T. Stafford Disaster Reliefand Emergency Assistance Act", el cual debe cumplir con todos los estatutos y exigencias federales. Uno de estos requerimientos de esta Ley federal, es que el Plan de Mitigación debe ser revisado y actualizado cada cinco (5) años.

El Plan de Mitigación Estatal 2021 conocido como "PRSNHMP" por sus siglas en inglés, es el resultado de un esfuerzo conjunto conducido por el Comité Interagencial para la Mitigación de Riesgos Naturales y Tecnológicos, compuesto por la mayoría de las agencias gubernamentales, empresas privadas y sectores comunitarios de nuestra sociedad. Esto, como lo exige la Ley 20-2017 y la Ley Federal, antes mencionadas y de conformidad a la Guía Comprensiva de Preparación 101 (CPG 101, por sus siglas en inglés) de la "Federal Emergency Management Agency" (FEMA).

El objetivo fundamental del Plan de Mitigación Estatal es establecer todo tipo de estrategias efectivas para reducir las pérdidas potenciales que pudieran producir los peligros naturales y los peligros causados por el hombre. Este Plan describe cómo el gobierno evalúa las acciones de mitigación de forma costo-efectiva y establece prioridades, según se va desarrollando. Es un plan sumamente estratégico y dinámico que hace los ajustes necesarios en la medida que se va implementando, que, a su vez, considera de forma ponderada las acciones de mitigación del plan anterior. Un dato importante es el hecho de que este plan describe ampliamente como el Estado le brinda un apoyo total a los 78 municipios para que estos puedan, a su vez, desarrollar sus propios planes de mitigación. Lo anterior, brindando adiestramientos y asistencia técnica mediante talleres y conferencias con el apoyo de FEMA.

El desarrollo y culminación del Plan de Mitigación Estatal 2021 se lo debemos a el trabajo y dedicación del personal del Área de Mitigación del NMEAD, el apoyo y colaboración de la Dra. Sara Aponte, supervisora del proyecto, de la Oficina Central de Recuperación, Reconstrucción y Resiliencia (COR3). Igualmente, la significativa aportación de la Universidad de Puerto Rico y su Escuela Graduada de Planificación, mediante acuerdo colaborativo, fue esencial en la recopilación de la data científica utilizada en el desarrollo de este Plan.

Nino Correa Filomeno
Comisionado Interino NMEAD

GOBIERNO DE PUERTO RICO
OFICINA CENTRAL DE RECUPERACIÓN,
RECONSTRUCCIÓN Y RESILENCIA

El Plan de Mitigacion de Peligros Naturales de Puerto Rico y el Proceso de Recuperacion Estatal

Puerto Rico cuenta con una oportunidad histórica de recuperación y reconstrucción que le permitirá otorgar resiliencia a nuestra infraestructura, cuyo resultado será evitar desastres mayores en caso de que ocurra una situación de emergencia. Conscientes de la importancia de mantener vigente el Plan Estatal de Mitigación de Peligros Naturales de Puerto Rico (PEMPN), se ha atemperado este documento a los riesgos que podrían enfrentar el gobierno y la población de suscitarse sequías, roturas de represas, deslizamientos, vientos extremos, inundaciones, terremotos, así como fallas y fisuras. Personal especializado de nuestra Oficina Central de Recuperación, Reconstrucción y Resiliencia (COR3, por sus siglas en inglés), colaboró con el Negociado de Manejo de Emergencias y Administración de Desastres (NMEAD) y la Universidad de Puerto Rico (UPR), en el desarrollo de la actualización de este plan.

Como ejemplo de los cambios realizados al PEMPN, esta nueva versión integra, por primera vez, información relacionada al estado de las represas en la isla con el objetivo de acceder a fondos de la Agencia Federal para el Manejo de Emergencias (FEMA, por sus siglas en inglés) a través del *Rehabilitation of High Hazard Potential Dam Grant Program*. Este trabajo consiste en el establecimiento de una evaluación de sequía para la visualización de los efectos de este riesgo en Puerto Rico.

En un hecho novel, la academia fue parte de la redacción de este Plan Estatal de Mitigación de Peligros Naturales de Puerto Rico, a través de 24 universitarios graduados y 2 profesores mentores de la Escuela Graduada de Planificación (EGP) del Recinto de Río Piedras de la UPR. La referida colaboración ocurrió tras el otorgamiento de un acuerdo colaborativo entre el NMEAD y la UPR.

Como parte de los esfuerzos conducentes al nuevo PEMPN de 2021, el equipo de la academia realizó un análisis de vulnerabilidad de seis riesgos, tomando en cuenta la versión del año 2016. Estos son los escenarios que surgieron tras los embates de los huracanes Irma y María, los eventos sísmicos que ocurrieron desde finales de 2019 y que se prolongaron durante la mayoría del 2020, y se introdujo por primera vez el riesgo de enfermedades infecciosas y la posibilidad del desarrollo de una pandemia, como consecuencia de la experiencia vivida con el coronavirus conocido como COVID-19 que nos afecta al día de hoy. Aunque este nuevo PEMPN no presenta datos sobre el riesgo de la pandemia debido a que todavía nos encontramos atendiendo la situación de emergencia causada por el COVID-19, se espera que la actualización subsiguiente de este plan incorpore el análisis correspondiente con la información recopilada desde el año 2020.

De otra parte, el equipo universitario recibió el apoyo de expertos científicos en cada uno de los riesgos (Subject Matter Experts), quienes proveyeron información técnica, datos, así como validación de la información generada. De esta manera, logramos aunar esfuerzos entre agencias gubernamentales, la academia y los expertos en el tema de riesgos, para la confección de un plan que es muy necesario para planificar, anticipar riesgos y ejecutar proyectos que resulten en la recuperación y reconstrucción de Puerto Rico. Recordemos que nuestra isla, a diferencia de otros territorios, actualmente atiende activamente el manejo de tres desastres de naturaleza mayor, incluyendo lo relacionado a los huracanes Irma y María, terremotos y pandemia.

Agradezco a todo el equipo de COR3, NMEAD, UPR y los científicos que participaron y aportaron sus conocimientos y recomendaciones en el desarrollo del PEMPN Sin duda, Puerto Rico cuenta excelentes recursos para continuar juntos trabajando por la reconstrucción de una infraestructura resiliente y eficiente a favor del desarrollo socioeconómico de nuestro pueblo.

Ing. Manuel A. Laboy Rivera
Representante Autorizado del Gobernador (GAR)

La actividad ciclónica del año 2017 en el Océano Atlántico y el Mar Caribe fue una sin precedente donde se desarrollaron 17 tormentas tropicales y 16 huracanes de los cuales 6 fueron de categoría 4 o mayor. Los huracanes más importantes fueron Harvey, Irma y María. Puerto Rico fue impactado por dos de ellos, Irma y María, en un período de 2 semanas. La devastación y la pérdida de vida provocada por dichos huracanes fue como nunca antes vista en la Isla.

Puerto Rico no sólo se ha visto impactado por lo desastres naturales de huracanes y tormentas en los últimos años, sino que también hemos experimentado una serie de terremotos en el sur de la Isla. A finales del año 2019 comenzó la actividad sísmica que se extendió al año 2020. El terremoto de mayor magnitud ocurrió el 7 de enero de 2020 y con ello, pérdidas que sobrepasan los $1,000 MM.

El Plan Estatal de Mitigación de Riesgos Naturales es una herramienta fundamental que intenta minimizar la pérdida de vida y propiedad ante desastres naturales futuros. Es esencial que en su preparación se incorporen a todos los sectores que se pueden ver afectados para que el mismo sea uno comprensivo y útil. Dicho plan tiene una vigencia de cinco (5) años y el plan estatal actual vence el 2 de agosto de 2021. Dada a la importancia de revisar dicho documento en medio de la recuperación de los desastres experimentados, el Gobierno Puerto Rico tuvo la iniciativa de unir esfuerzos con la academia. Es por ello que la Escuela Graduada de Planificación de la Universidad de Puerto Rico ha tenido un rol activo en la corriente revisión al plan que redunda en varios beneficios. El primero, realizar la revisión con profesionales capacitados en un periodo corto de tiempo y el segundo, capacitar a los estudiantes graduados.

Como Oficial de Mitigación del Estado, manejo el programa de mitigación de riesgos naturales que es subvencionado con fondos de FEMA. Actualmente, Puerto Rico maneja el fondo más grande en la Nación. Es de suma importancia tener un plan estatal de mitigación robusto para así poder formular proyectos que atiendan los verdaderos problemas que enfrentamos y de la misma forma, minimizar el impacto de futuros desastres naturales.

Ivelysse Lebrón Durán, MSME, PE
Directora Programa Mitigación de Riesgos / Oficial de Mitigación del Estado (SHMO)

Planificación
escuela graduada

La Escuela Graduada de Planificación (EGP) de la Universidad de Puerto Rico Recinto de Río Piedras es la única institución en Puerto Rico que desarrolla el campo de la planificación hace más de cinco décadas, formando profesionales a la vez que produciendo conocimiento para el análisis de políticas públicas, planes y proyectos de diversas escalas y ámbitos de la realidad puertorriqueña. A partir de la década del año 1990 la Escuela dedica esfuerzos para avanzar en la producción de datos para el análisis espacial de las condiciones geográficas de Puerto Rico, basados en el uso de la tecnología para procesamiento de imágenes aéreas, plataformas de sistemas de información geográfica (SIG) y de toma de decisiones. Unos de los resultados ha sido el Instituto de Investigación y Planificación Costera (CoRePI-PR en inglés), generador de amplia investigación, datos y análisis enfocados en las costas de Puerto Rico, liderado por la Dra. Maritza Barreto. Dotada de equipo tecnológico profesores y profesoras desarrollando estos recursos, la Escuela se posiciona como un centro de apoyo al gobierno y sociedad puertorriqueña hasta el presente, siendo esta colaboración para el Plan Estatal de Mitigación de Riesgos Naturales 2021una de las más recientes.

La iniciativa de contribuir a la actualización de segmentos del Plan de Mitigación Estatal ocurre dado el entusiasmo de los profesores y estudiantes de la Escuela que realizaron el trabajo de manera voluntaria. Las tareas formaron parte de requisitos académicos de la unión de dos cursos; uno enfocado en riesgos y otro en el análisis espacial para la planificación, de la profesora Dra. Maritza Barreto y el profesor Aurelio Castro respectivamente. Veinticuatro (24) estudiantes participaron en el desarrollo de un perfil de riesgos basado en el análisis geoespacial de datos existentes parar eventos tales como vientos fuertes, inundaciones, deslizamientos, sequia, terremoto, y fallas geológicas. El trabajo incluyó la evaluación de varios componentes de vulnerabilidad social e infraestructura crítica para cada escenario de riesgo. Además, se realizó un acopio de datos geoespaciales para cada uno de los seis riesgos estudiados. La contribución al Plan consiste de este producto sobre riesgos exclusivamente, que sirvió a su vez para el desarrollo de las destrezas y capacidades de los estudiantes que luego se unen campo laboral en el área de desastres.

Si bien el insumo de parte de la Escuela para la actualización del Plan se limitó a dicho análisis, la colaboración abrió las puertas para futuras alianzas para el beneficio perdurable tanto del gobierno de Puerto Rico en el área de desastres, como de la Universidad. Esta iniciativa es muestra del compromiso de la Escuela de continuar aportando a una transformación de los acercamientos metodológicos y analíticos que inciden sobre la planificación y política pública de Puerto Rico desde el rigor académico que le caracteriza.

Norma I. Peña

Dra. Norma Peña Rivera
Directora Interina, Escuela Graduada de Planificación

HAZARD MITIGATION PLANNING PARTNERS

The planning process kicked off on August 19, 2019. The PRSNHMP 2021 introduced new partners that supported this effort. For the first time, the Academy is incorporated as part of one of the working groupsresponsible for conducting risk analysis as well as validation of existing data and information anddevelopment of strategies aligned with the vision of state and local governments. Twenty Four graduate students from the UPR Graduate School of Planning worked on this monumental task.

The collaborators were the following:

-Carla N. Matos Chévere
-Doris Medina Hernández
-Augusto Y. Miranda Acevedo
-Clery Morales Torres
-Yvette M. Núñez Sepúlveda
-Laura Ospina Gómez
-Brian Rodríguez-Acevedo
-Jailyn Soto-Quintana
-Julianne N. Talavera Gerena
-Mariángela Tirado Vales
-Génesis Valentín-Rivera
-Jaime Villeta García

Orientation of the 2021 PRSNHMP update process to UPR-GSP students. January, 2020.

-Moisés Abdel-Rahman López
-Katia Avilés-Vázquez
-Valeria Bonano-Suazo
-Keyshla N. Class Villanueva
-Natalia P. Crespo Román
-Grace M. Delgado Navarro
-Nicole N. García Jiménez
-Nias Hernández Montcourt
-Enery M. López Navarrete
-Mariana López-González
-Brian Lozano Hernández
-Rubén O. Maldonado González

Mentoring Professors

-Dr. Maritza Barreto Orta - Natural/Anthropogenic Hazards and Planning.
-Prof. Aurelio Castro Jiménez – Advanced Geographic Information Systems.
-Dr. Norma I. Peña Rivera - Director, UPR Graduate School of Planning.

Special Thanks to:

-Victor Huérfano, Puerto Rico Seismic Network.
-Christa G. von Hillebrandt-Andrade, Caribbean Tsunami Warning Program.
-Ernesto Rodriguez, National Oceanic and Atmospheric Administration.
-Luis D. Aponte Bermúdez, Ph.D., P.E., Structural and Wind Engineer.

List of Acronyms

ACRONYMS	SPANISH	ENGLISH
AAA	Autoridad de Acueductos y Alcantarillados	Aqueduct and Sewer Authority
AAFAF	Autoridad de Asesoria Financiera y Agencia Fiscal	Puerto Rico Fiscal Agency and Financial Advisory Authority
AEE	Autoridad de Energía Eléctrica	Electric Power Authority
AEP	Autoridad de Edificios Públicos	Public Buildings Authority
AFI	Autoridad para el Financiamiento de la Infraestructura	Infrastructure Financing Authority
AP	Autoridad de Puertos	Port Authority
BCA	Análisis de Costo-Beneficio	Benefit-Cost Analysis
CAO	Oficina del Área del Caribe	Caribbean Area Office
CariCOOS	Sistema de Observación Costera del Caribe	Caribbean Coastal and Observation System
CCCPR	Consejo del Cambio Climático de Puerto Rico	Puerto Rico Climate Change Council
CDBG	Subvención en Bloque para Desarrollo Comunitario	Community Development Block Grant
CDBG-DR		
CDC		Centers for Control Disease and Prevention
CERT	Programa de Equipos Comunitarios de Respuesta a Emergencias	Community Emergency Response Teams
CFR	Código de Regulaciones Federales	Code of Federal Regulations
CLCC	Cooperativa para la Conservación del Paisaje en el Caribe	Caribbean Landscape Conservation Cooperative
COR3	Oficina Central para la Recuperación y Reconstrucción de Puerto Rico	Central Office for Recovery and Reconstruction of Puerto Rico
CSC	Centro de Ciencia del Clima	Climate Science Center
DMA	Ley de Mitigación de Desastres	Disaster Mitigation Act
DRNA	Departamento de Recursos Naturales y Ambientales	Department of Natural and Environmental Resources
EAS	Sistema de Alerta de Emergencia	Emergency Alert System
EMI	Instituto de Manejo de Emergencias	Emergency Management Institute
EMPG	Programa de Subvenciones para el Desempeño de Manejo de Emergencias	Emergency Management Performance Grant
EWP	Programa de Emergencias de Protección de Cuencas	Emergency Watershed Protection
FEMA	Agencia Federal para el Manejo de Emergencias	Federal Emergency Management Agency
FIRM	Mapas sobre Tasas de Seguro de Inundación	Flood Insurance Rate Maps

Acronyms	Spanish	English
FMA	Asistencia de Mitigación Contra Inundaciones	Flood Mitigation Assistance Program
GAR	Representante Autorizado del Gobernador	Governor's Authorized Representative
GIS	Sistema de Información Geográfica	Geographical Information System
GPR	Gobierno de Puerto Rico	
HHPD		High Hazard Potential Dam Program
HHS		US Department of Health and Human Services
HMGP	Programa de Subvención de Mitigación de Riesgos	Hazard Mitigation Grant Program
ICBO	Conferencia Internacional de Oficiales de Construcción	International Conference of Building Officials
ICC	Consejo Internacional de Códigos	International Code Council
IITF	Instituto Internacional de Bosques Tropicales	International Institute of Tropical Forest
JP	Junta de Planificación de Puerto Rico	Puerto Rico Planning Board
NCSU	Universidad Estatal de Carolina del Norte	North Carolina State University
NCWCG	Programa Nacional para la Conservación de Humedales Costeros	National Coastal Wetlands Conservation Grant Program
NDSP	Programa de Seguridad Nacional de Presas	National Dam Safety Program
NEON	Red Nacional de Observatorios Ecológicos	National Ecological Observatory Network
NFIP	Programa Nacional de Seguros contra Inundaciones	National Flood Insurance Program
NMEAD	Negociado para el Manejo de Emergencias y Administración de Desastres de Puerto Rico	Puerto Rico Emergency Management Bureau
NOAA	Oficina Nacional de Administración Oceánica y Atmosférica	National Oceanography and Atmospheric Administration
NSF	Fundación Nacional de las Ciencias	National Science Foundation
OIGPe	Oficina del Inspector General de Permisos	Office of the Chief Permit Inspector
OGP	Oficina de Gerencia y Presupuesto	Office of Management and Budget
OGPe	Oficina de Gerencia de Permisos	Permit Management Office
OMME	Oficina Municipal de Manejo de Emergencia	Municipal Emergency Management Office
OMS	Organización Mundial de la Salud	World Health Organization
P3		Puerto Rico Public-Private Partnership Authority
PDM	Programa de Mitigación Pre-Desastre	Pre-Disaster Mitigation Grant

ACRONYMS	SPANISH	ENGLISH
PEMPN	Plan Estatal de Mitigación de Peligros Naturales de Puerto Rico	Puerto Rico State Natural Hazards Mitigation Plan
PIB	Producto Interno Bruto	Gross Domestic Product
PMZC	Programa de Manejo de la Zona Costera	Coastal Zone Management Program
POT	Plan de Ordenación Territorial	Territorial Ordinance Plan
PRBC	Código de Construcción de Puerto Rico	Puerto Rico Building Code
PROMESA		Puerto Rico Oversight, Management, and Economic Stability Act.
PUCPR	Pontificia Universidad Católica de Puerto Rico	Pontifical Catholic University of Puerto Rico
PUT	Plan de Uso de Terrenos	Land-Use Plan
RSPR	Red Sísmica de Puerto Rico	Seismic Network of Puerto Rico
SCO		State Coordination Officer
SECC	Comité Estatal de Comunicaciones de Emergencia	State Emergency Communications Committee
SHMO	Oficial Estatal de Mitigación de Riesgos	State Hazard Mitigation Officer
SIP	Sistema Integrado de Permisos	Integrated Permit System
SRO-ZMT	Sistema de Referencia Oficial para el deslinde de la Zona Marítimo Terrestre	Official Maritime Terrestrial Zone Reference System
STAPLEA	Social, Técnico, Administrativo, Político, Legal, Económico, y Ambiental	Social, Technical, Administrative, Political, Legal, Economic, and Environmental
UMET	Universidad Metropolitana de Puerto Rico	Metropolitan University of Puerto Rico
UPPR	Universidad Politécnica de Puerto Rico	Polytechnic University of Puerto Rico
UPR	Universidad de Puerto Rico	University of Puerto Rico
USACE	Cuerpo de Ingenieros de los Estados Unidos	United States Army Corps of Engineers
USFWS	Servicio de Pesca y Vida Silvestre de Estados Unidos	United States Fish & Wildlife Service
USFS	Servicio Forestal de los Estados Unidos	United States Forest Service
USGS	Servicio Geológico de los Estados Unidos	United States Geological Survey

INVESTMENT IN REDUCTION; SAVINGS IN RECONSTRUCTION

The 2021 Puerto Rico State Natural Hazard Mitigation Plan (PRSNHMP) provides long- term solutions to hazards that can prevent the disruption of a community's daily activities, reduce property damage, and save lives. Threats, worsened by climate change, have the potential of creating disasters that endanger the well-being of the entire community impacting life, property, economy, and natural systems, among others. The 2021 PRSNHMP identifies risks and develops mitigation measures to reduce vulnerability to natural hazards.

The revision of the 2021 PRSNHMP takes place at a significant period, where the Government of Puerto Rico (GPR) experiences socio-economic particularities that directly impact the GPR's ability to propose and execute strategies in both natural hazard mitigation, as in all administrative and operational areas of the Government. Amid Puerto Rico's financial crisis, Congress enacted the Puerto Rico Oversight, Management, and Economic Stability Act (PROMESA).[1] Consequently, Puerto Rico is fiscally limited and faces a recession in economic activity, thus impacting the labor force due to the significant reduction in the resources available to serve government operations. As a result, Puerto Rico has altered its population growth at a negative rate, mainly due to the high migration of islanders to the Continental U.S. in search of more favorable economic conditions for their families, primarily in different states of the United States. This trend continues, as confirmed by the U.S. Federal Census and will have a significant effect on urban population concentrations.

The Caribbean and Puerto Rico are at risk of natural hazards such as storms and hurricanes. In 1928 and 1932, Puerto Rico was impacted by Hurricanes San Felipe and San Ciriaco during a deep economic depression in the 1930s. Moreover, between 1989-1998 Hurricanes Hugo, Hortense and Georges struck the Island leaving thousands of homeless inhabitants and wrecking the Island's infrastructure resulting in loss of life. For example, Hurricane Hugo had wind velocities in San Juan measured at up to 100 mph; wind gusts elsewhere measured as

[1] **Public Law 114 - 187** – "Puerto Rico Oversight, Management, And Economic Stability Act" Or "PROMESA."

high as 140 mph. The Centers for Disease Control and Prevention (CDC) reported damaged 25% of homes in Puerto Rico, 75% of the Island left without power, and heavy rains caused flash flooding. The medical examiner in Puerto Rico investigated nine (9) deaths considered to be related to the hurricane. One death (case 1) occurred before the storm (pre-impact phase); two (cases 2 and 3), during the storm (impact phase); and six (cases 4-9), after the storm (post-impact).[2]

After 20 years of these atmospheric events, on September 6, 2017, Hurricane Irma made landfall over the East of Puerto Rico as a Category 3 storm, with winds of more than 110 miles per hour. The effects were more than one million residents without electrical power, 1,448 homes moderately damaged, 32 extensively damaged, and 50 destroyed.[3] The ocean surface temperature was higher than 86 degrees Fahrenheit more than enough to stay in Category 4. Throughout Puerto Rico, 781 out of 1,600 telecommunications towers went out of commission, primarily due to power outages. At least 362,000 customers lost water services. Debris, mostly fallen trees, blocked at least 72 roads. This event left 900,000 people without electricity, and the estimated damage caused exceed 600 million in infrastructure areas, without including road damage. Additionally, approximately $30 billion in damage to the agricultural sector was estimated.

Afterward, the first Category 4 hurricane to directly impact Puerto Rico in 85 years, Hurricane Maria, made landfall on September 20, 2017. This disaster, coming mere weeks after Hurricane Irma, brought a massive storm surge, heavy rains, and sustained winds of 155 mph (160 km/h), flattening neighborhoods and crippling the Island's power grid. Maria's center crossed the southeast coast of Puerto Rico near Yabucoa and moved northwestward. Every Municipality was devastated by this catastrophic natural disaster resulting in overwhelming losses in the Commonwealth. These two atmospheric phenomena devastated the Island, especially Hurricane Maria, leaving thousands of Puerto Ricans without critical infrastructure (housing, electricity, water, road system, and telecommunications). The event caused

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[2] Deaths Associated with Hurricane Hugo – Puerto Rico
https://www.cdc.gov/mmwr/preview/mmwrhtml/00001476.htm (accessed 03/23/2020)

[3] *Housing Damage Assessment and Recovery Strategies Report Puerto Rico (PDF) (Report)*. **United States Department of Housing and Urban Development.** June 29, 2018. p. 19. Retrieved January 22, 2020.

millionaire damages and intensified the economic crisis by threatening to continue the exodus of Puerto Ricans to the United States.

On January 7, 2020, Puerto Rico experienced the worst earthquake in more than 100 years, a magnitude 6.4. The quake triggered widespread power outages and damage, paralyzing the Island. The bulk of the earthquake damage was in the southern coastal region, from Ponce west to the municipalities of Yauco, Guayanilla, Lajas, and Guánica. The expectations from USGS's preliminary reports indicate that the economic damage resulting from this earthquake will be around $838 million (1% of P.R.'s GDP). On January 16, 2020, President Donald J. Trump issued a Major Disaster Declaration designing the following areas as adversely affected: Yauco, Peñuelas, Guánica, Guayanilla, San Germán, and Ponce. Subsequently, on January 22, 2020, *Amendment No. 1 to Notice of Major Disaster Declaration* added the following areas: San Germán, Adjuntas, Cabo Rojo, Corozal, Jayuya, Lajas, Lares, San Sebastián, and Villalba. There are currently 39 shelters located in fourteen (14) municipalities holding 5,605 people who were affected by the earthquakes. The initial property damage assessment by category identifies: 111 destroyed, 460 major, 513 minor, and 474 affected. This series of unfortunate events represents a significant challenge for Puerto Rico, which has yet to recover from the devastating effects of Hurricanes Irma and Maria. Moreover, the continuous aftershocks have disrupted the municipalities of Ponce, Yauco, Cabo Rojo, and Maricao, among others, in their ability to swiftly complete the local mitigation planning process on time for the obligation.

On January 30, 2020, the World Health Organization (WHO) declared Coronavirus Pandemic (COVID-19) a public health emergency of international importance. On January 31, 2020, the Secretary of the United States Department of Health and Human Services (HHS) declared a public health emergency for the United States. On March 11, 2020, the WHO declared a pandemic for COVID-19. The declaration comes with some 114 countries affected, reported cases and fatalities globally, with China being the most impacted country so far. On March 15, 2020, through the Executive Order 2020-023, the Governor of Puerto Rico, Hon. Wanda Vázquez-Garced, implement the necessary closure of governmental and private sector operations to combat the effects of COVID-19 and to control the risk of infection within the Island.

Per the President's Declaration of National Emergency for a COVID-19 issued on March 13, 2020, the Federal Emergency Management Agency (FEMA) recommends implementing appropriate measures that are necessary to protect public health and safety, consistent with public health guidance and the conditions and capabilities in their jurisdictions. FEMA provides the following advice on the types of emergency protective measures that may be eligible under FEMA's Public Assistance Program (P.A.) according to the COVID-19 Declaration of Emergency to ensure that resource limitations do not impede efforts to respond to this unprecedented disaster. Chapter 4 of this Plan will provide details of this information.

HAZARD MITIGATION

Hazard mitigation defines any action taken to mitigate, reduce, or eliminate the long-term risk to human life and property from natural hazards.[4] A hazard is any natural event or condition with the likelihood to cause loss of life, harm, damage, infrastructure damage, agricultural failure, environmental damage, business interruption, or other structural and economic loss.

The purpose of hazard mitigation is to reduce the community vulnerability to disasters and their effects, promote individual and community safety and resilience as well as protect the federal investment. Government of Puerto Rico's hazard mitigation measures include, but are not limited to, the following:

- Development of mitigation standards, regulations, policies, and programs.
- Implementing 2018 building codes and Code enforcement.
- Municipal planning and land use/zoning policies.
- Dam safety program, seawalls, and levee systems.
- Floodplain management regulations and stormwater regulations.
- Open space program and acquisition of flood-prone and environmentally sensitive lands.
- Protecting critical services.

[4] *See* **44 CFR** § 201.2 Definitions

- Retrofitting/hardening/elevating structures and critical facilities.

AUTHORITY

Meeting the requirements of Section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act or the Act), 42 USC. 5165, enacted under Sec. 104 the Disaster Mitigation Act of 2000, (DMA 2000) Public Law 106-390 of October 30, 2000, keeps the GPR eligible to apply for disaster assistance, including hazard mitigation grants, available through the Robert T. Stafford Disaster Relief and Emergency Assistance Act, P.L. 93- 288, as amended.

The PRSNHMP responds to the mandate of the DMA, as amended. This mechanism provides the legal basis for FEMA to define and establish the requirements and conditions to the State and Local (Municipal) governments, to receive federal financial aid to mitigate damage that may cause natural hazards. Section 1.2.1. will present the legal and administrative components which framed this Plan.

ASSURANCE

In compliance with 44 Code of Federal Regulations (CFR) 13.11 (c), the 2021 PRSNHMP will comply with all applicable federal statutes and regulations to the periods for which it receives grant funding. Also, it will amend its Plan whenever necessary to reflect changes in state or federal laws and statutes as required in 44 CFR 13.11 (d).

Puerto Rico has effectively complied with the requirements of this Act since its inception, and this document intends to update the 2016 PRSNHMP (adopted on May 17, 2016). It is important to note that federal regulations established three (3) years as a period to review State Mitigation Plans. However, on April 25, 2014, the Mitigation Planning Regulations were amended in the 44 CFR Part 201 to reduce the frequency of the State Plan update from three (3) to five (5) years. This amendment was effective on May 27, 2014 and had the effect of amending the validity of Puerto Rico's Natural Hazard Mitigation Plan from 2011 to September

15, 2016. The 2021 PRSNHMP update follows FEMA's *State Mitigation Plan Review Guide*, implemented on March 6, 2016, and replaced the *Multi-Hazard Mitigation Planning Guidance Under the Disaster Mitigation Act of 2000* (January 2008).

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CHAPTER I

INTRODUCTION AND BACKGROUND

Courtesy by FEMA

1.1 GENERAL CONSIDERATIONS

The foundations of strategic planning and mitigation are to identify and develop measures and policies to enhance awareness of risks and efforts to improve community preparedness, resilience, and sustainability in the face of both natural and human-caused hazards. Besides, it promotes the development of a process that serves as the basis for studying the magnitude and potential effects that these natural hazards can have on the urban fabric. The 2021 **Puerto Rico State Natural Hazard Mitigation Plan (2021 PRSNHMP)** conveys the formulation and implementation of mitigation strategies for the GPR through proactive interventions to properly prepare and reduce the adverse effects in life and property caused by a natural hazard.

The Strategic Planning standard used in this revision provides the theoretical framework which allows identifying the strengths and weaknesses of the system within its geographical, political, and economic environment. Its purpose is to propose strategies or courses of action to the range of problems it faces, specifically regarding the study and management of natural hazards and those created by human activity causing potential dangers to the country's life, property, and ecosystems. This framework is complemented with hazard mitigation best practices to close the gap that often exists between hazard mitigation planning and other local planning and regulatory land-use processes. It also guides how to integrate hazard mitigation strategies into comprehensive and functional plans and shows where hazard mitigation can fit into zoning and subdivision codes. The framework incorporates the policies and procedures that guide the limitations and benefits that planners and governments are confronting within all types of natural disasters.

Additionally, the 2021 PRSNHMP is supplemented by a community-wide approach that fosters horizontal and vertical integration of the Local Hazard Mitigation Plans (LHMP, local/municipal planning). Both methods identified eleven (11) hazards that pose a threat to the communities throughout the Government of Puerto Rico (GPR). According to the Local Mitigation Plans already approved and adopted, the top risks predominately and consistently identified were the following six (6):

- Flooding (riverine and coastal)
- Landslides
- Heavy winds
- Earthquake
- Geological faults and fissures
- Droughts

These top hazards represent the result of the review and screening/identification process and are also determined as the most critical statewide.

For the first time, the 2021 PRSNHMP's Planning Steering Committee welcomed recommendations made by the Puerto Rico Safety Dam Officer to incorporate dam failure as a risk in the 2021 PRSNHMP and to access High Hazard Potential Dams program funds in the event of an emergency. This update includes a general vulnerability analysis for the 37 dams in Puerto Rico and will offer some mitigation strategies. The subsequent update will provide a more in-depth analysis of this risk and a more comprehensive approach.

Although Local Plans do not take the infectious diseases/pandemia as a hazard, it will be included in the next plan update to ensure more official data and statistics once the current emergency is addressed. The Plan presents a strategy that has the potential to reduce or eliminate the risks and vulnerabilities associated with the identified hazards.

The most outstanding achievement of the 2021 PRSNHMP is the exceptional contributions and support of academia. This responsibility fell to the University of Puerto Rico Graduate School of Planning (UPR-EGP) for its technical and scientific expertise in the areas of mitigation risk.

1.2 PURPOSE OF THE PLAN

The primary purpose of the 2021 PRSNHMP is to reduce the GPR's vulnerability caused by the impact of natural hazards through the formulation of a coordinated mitigation strategy between the State, Municipalities, Non- Governmental Organizations, and communities. The 2021 PRSNHMP foresees the development of government policies on mitigation that meets the requirements established by the Federal Emergency Management Agency (FEMA). The mitigation strategies in the Plan must continuously evolve to develop and respond to multiple socio-economic changes, demographic and environmental issues experienced.

1.3 CONCEPTUAL CONTEXT

1.3.1 Emergency Management Principles.

Community preparedness for all disasters requires identifying resources and expertise in advance and planning how these can be used in a disaster. However, preparedness is only one phase of emergency management.

The fundamental principles of emergency management are based on four phases – mitigation, preparedness, response, and recovery. The following diagram illustrates the four phases of emergency management.

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Figure 1-1: Emergency Management Principles Diagram.

Preparedness is the process of planning effective response to emergencies or disasters by coordinating and utilizing available resources. Preparedness activities take place before an emergency occurs.

The Response stage consists of those activities aimed at mitigating the immediate and short-term effects created by an emergency or disaster situation. The response actions include those aimed at saving and protecting lives, property and meeting basic human needs. It includes actions taken to save lives and prevent further property damage in an emergency. Response is putting preparedness plans into action, while those activities take place during an emergency. Based on the circumstances and requirements of each situation, PREMB will aid municipal governments as established in the State Emergency Management Plan, using the partial activation of total number of agencies in charge of the functions Federal Emergency Support Services (ESF) that are necessary.

The Recovery stage is the process used to restore the affected area to pre-disaster conditions or improved according to the mitigation. It includes actions taken to return to a normal or an even safer situation following an emergency. Mitigation is sustained action aimed at eliminating or reducing the risk or impact of natural hazards to life and property.

The mitigation phase includes any activities that prevent an emergency, reduce the likelihood of occurrence, or reduce the damaging effects of unavoidable hazards. Mitigation activities should be considered long before an emergency.

1.3.2 Legal Framework.

Disaster Mitigation Act of 2000 (DMA) (42 USC §5133).
The Disaster Mitigation Act of 2000, (Public Act 106-390), amendments to the Robert T. Stafford Disaster Relief and Emergency Assistance Act, known as the "Stafford Act" (§ 5121 ss.), to establish a national disaster and hazard mitigation program; specify a pre-disaster mitigation program; delimit the administration of disaster relief; require disaster mitigation plans for state, local, and tribal governments as a requirement for federal aid;control federal costs of disaster assistance; among other purposes.

The State Mitigation Plan Review Guide, effective since March 2016 (F.P. 302-094-2), sets out FEMA's official policy and interpretation regarding the requirements for risk mitigation plans. The guide emphasizes that having a state risk mitigation plan demonstrates a commitment to reducing natural hazard risks and directions decision- making to reduce the effects of natural risks by committing resources to it.

The use of this guide is critical to facilitating consistent evaluation, approval of state mitigation plans, and updating mitigation plans. The guide is divided into four sections: Section 1 presents the introduction, purpose, principles, and organization of the guide. Section 2 establishes responsibilities within the mitigation planning of FEMA and the State. Section 3 details the requirements that a state plan must have, including planning, hazard identification, and risk assessment; mitigation strategies; local coordination and mitigation capacity; review, evaluation, and implementation of the Plan; adoption of the Plan and guarantees; and repetitive loss strategies. Finally, Section 4 presents the requirements for establishing an enhanced state Plan. An enhanced mitigation plan is a FEMA designation where it recognizes a state's proactive or in-process coordinated efforts to implement a comprehensive program that reduces losses, protects life and property, and creates safe communities.

Such a plan results in eligibility to apply for more funds from the Hazard Mitigation Grant Program (HMGP).

Code of Federal Regulations, Part 201, Section 201.1 – 201.5 (44 CFR Part 201 §201.1-201.05) – Mitigation Planning, (CFR).

Part 201 of the CFR provides information on policies and procedures for Mitigation Planning. It provides the requirements for the establishment of mitigation plans by indigenous states and tribes, as required by the Stafford Act, USC §5121 ss.

The CFR establishes that the purpose of a state or tribal mitigation plan is to identify the natural hazards and risks that impact them, identify actions and activities to reduce the loss of those risks, and establish a coordinated process for implement the Plan taking advantage of a variety of resources.

Section 201.4 establishes that states must have approved a Standardized Mitigation Plan that meets the requirements of that section to receive grants from "non-emergency" classified funds under the Stafford Act and FEMA mitigation funds. A mitigation plan is demonstrative of the State's commitment to reducing risks from natural disasters and serves as a guide for decision-makers to commit resources to minimize the effect of natural disasters.

Puerto Rico Homeland Security Department Act - Law No. 20 of April 10, 2017.

Law No. 20 of April 10, 2017, in Chapter 6, creates the "Puerto Rico Emergency Management Bureau" (PREMB) for local, state government, or its instrumentalities. This is under the provisions of the Stafford Act 93-288, as amended. PREMB coordinates the GPR and the U.S. Government's efforts when there is a presidential declaration of emergency or disaster.

There will be a Commissioner who will coordinate the GPR disaster management plans and programs with those of the U.S. Government through the Inter-agency Committee for the Mitigation of Natural and Technological Risks. The Committee is responsible for: (a) preparing and implementing the State Mitigation Plan; (b) prioritize mitigation projects; and c) assess the nature of emergency or disaster damage and recommend mitigation actions to reduce future damage.

Presidential Declarations for Hurricane Maria.

FEMA 4339-DR-PR is the major disaster declaration signed by the United States President on September 20, 2017. It declared that the 78 municipalities of the GPR affected are eligible for Public Assistance (PA), Individual Assistance (IA), and Hazard Mitigation Grant (HMGP), under the Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 USC §§5121-5207).

By public notice, FEMA announces the intention to reimburse eligible participants for costs eligible to repair and replace facilities damaged by Hurricane Maria, resulting from September 17, 2017, and beyond. Also, historic properties and wetlands that affect the floodplain may result in continued vulnerability from flood damage.

OE-2019-062 - Reaffirms and expands the Government's public policy for the effective and transparent management of federal funds to reconstruct the Island.

Delegates the power to establish a rigorous oversight structure and compliance mechanisms to the Puerto Rico Fiscal Agency and Financial Advisory Authority (PRFAFAA) to ensure the appropriate and efficient use of federal funds.

OE-2017-065 – Creation of the Puerto Rico Central Office of Recovery and Reconstruction (COR3).

On October 23, 2017, through Executive Order OE-2017-065, the Governor authorizes the creation of the Puerto Rico Central Office for Recovery and Reconstruction of Puerto Rico (COR3), with the purpose of (a) identifying, procuring and administering all state, federal and/or private resources available to the GPR or any government entity to invest in the recovery; (b) coordinate and channel all efforts and activities of the GPR and its entities in the recovery; (c) finance, implement or cause recovery-related infrastructure works and projects; and (d) advise the Governor and offer assistance, and technical advice to government entities on any matter of recovery.

The faculties given to the COR3 include, but are not limited to: (a) developing and promoting short-, medium-and long-term plans for recovery; (b) propose and promote the implementation of special programmes dedicated to recovery; (c) identify and procure available funds and resources for recovery; as well as innovative alternatives to finance the recovery process; (d) establish priorities and plans for the coordination and allocation of resources related to recovery; (e) coordinate with governmental entities and community organizations the development of local and regional recovery plans; (f) ensure that the contracts and instruments necessary to exercise the powers laid down in the executive order are granted; (g) approve recovery-related policy or regulation; (h) manage recovery-related resources and programs; (i) formulate, adopt, amend and repeal timetables on the progress of the recovery; (j) formulate, adopt, amend and repeal audit and compliance policies; (k) develop and implement robust ethics, compliance and auditing programs; (l) develop, submit, and initiate proposals to request the allocation of funds and resources for recovery, whether under state, federal, or private programs; (m) formulate, adopt, amend or repeal processes for implementing proposals that are approved; (n) coordinate and collaborate with the State Coordinating Officer and the authorized representative of the Governor; (o) exercise rights and powers conferred on the Puerto Rico Public-Private Partnership

Authority (P3) under Law No. 29-2009, which are not inconsistent with the Executive Order; (p) perform all acts or measures to carry out the purposes and powers conferred in the Executive Order.

OE-2017-069-Incorporates the participation of the Governor's Authorized Representative (GAR). Through the Executive Order, OE-2017-069, the OE-2017-065 is amended to clarify several aspects of it. Section One states that the COR3 is created as a division within the P3 with the purpose of (a) identifying and procuring all state, federal and/or private resources available to government entities to invest in the recovery; (b) coordinate and channel efforts and activities of governmental entities related to recovery; (c) finance, implement or cause recovery-related infrastructure works and projects; and (d) advise the Governor and provide assistance and technical advice to other government entities on the issue of recovery.

Section Two's amendment states that COR3 is subject to the duties and powers of the P3. It also establishes the controls, which it may carry out, among which is provided in section "N" which will collaborate with the State Coordinating Officer (SCO) and the Authorized Representative of the Governor (Governor's Authorized Representative (GAR) to assist both and avoid duplication of work. The COR3 is responsible for incorporating in its administrative processes the participation of the SCO, the GAR, or others.

The amendment to Section Four of OE-2017-065 states that COR3 shall be directed by the Executive Director of the P3 or by the executive officer to whom they delegate. The amendment to Section Eight of OE-2017-065 defines the term governmental entity. It refers to any department, agency, board, commission, negotiated, office, public corporation, or instrumentality of the Executive Branch of the GPR, which is currently existing or that is believed in the future. Finally, OE-2017-069 renders ineffective any other executive order that is in whole or in part incompatible with it, to the extent that such incompatibility exists.

Law 33-2019, Puerto Rico's Climate Change Mitigation, Adaptation, and Resilience Act.
On May 22, 2019, Puerto Rico's Climate Change Mitigation, Adaptation, and Resilience Act, Law No. 33 of May 22, 2019, as amended, was passed. This Law establishes the public policy of the Government of Puerto Rico regarding climate change and the processes of mitigation, adaptation, and resilience by sector. Also, it orders the establishment of an inventory of greenhouse gas emissions, the approval of a Climate Change Mitigation, Adaptation, and Resilience Plan. Also, set it up a Committee of Experts and Advisers on Climate Change and a Joint Commission to mitigate, adapt, and resilience to climate change in the Legislative Assembly. The Memorandum to this legislation recognizes that a variety of studies have been conducted in Puerto Rico on the adverse effects of not addressing climate change on the Island (Puerto Rico's Climate State: Vulnerability Assessment Socio-ecological of Puerto Rico in a Changing Climate (2013); Path to Resilience; Puerto Rico Climate Change Adaptation

Strategies Guide (NOAA, 2015); Daytime temperature range in Puerto Rico 1950-2014 (Méndez Tejada, 2015); Energy Resource Catalog of the University of Puerto Rico (INESI); Climate Change Adaptation Plan (DRNA, 2016)); however, there is no coordinated plan that integrates the different sectors and directs work to assess and achieves the proposed metrics and objectives.

This legislation seeks to establish, among other things, concrete metrics, particular objectives. It guides to develop a Climate Change Mitigation, Adaptation, and Resilience Plan, to be developed under the recommendation of a group of experts to form the Committee of Experts and Advisers on Climate Change. The Act establishes the means to develop tools to achieve exact parameters and targets about energy efficiency and the new Renewable Energy Portfolio under the Puerto Rico Public Energy Policy Act and Law 82-2010. Finally, it contains initiatives and recommendations resulting from the efforts made by the Multi sectorial Working Group on Climate Change created through the Executive Order 2018-45.[1]

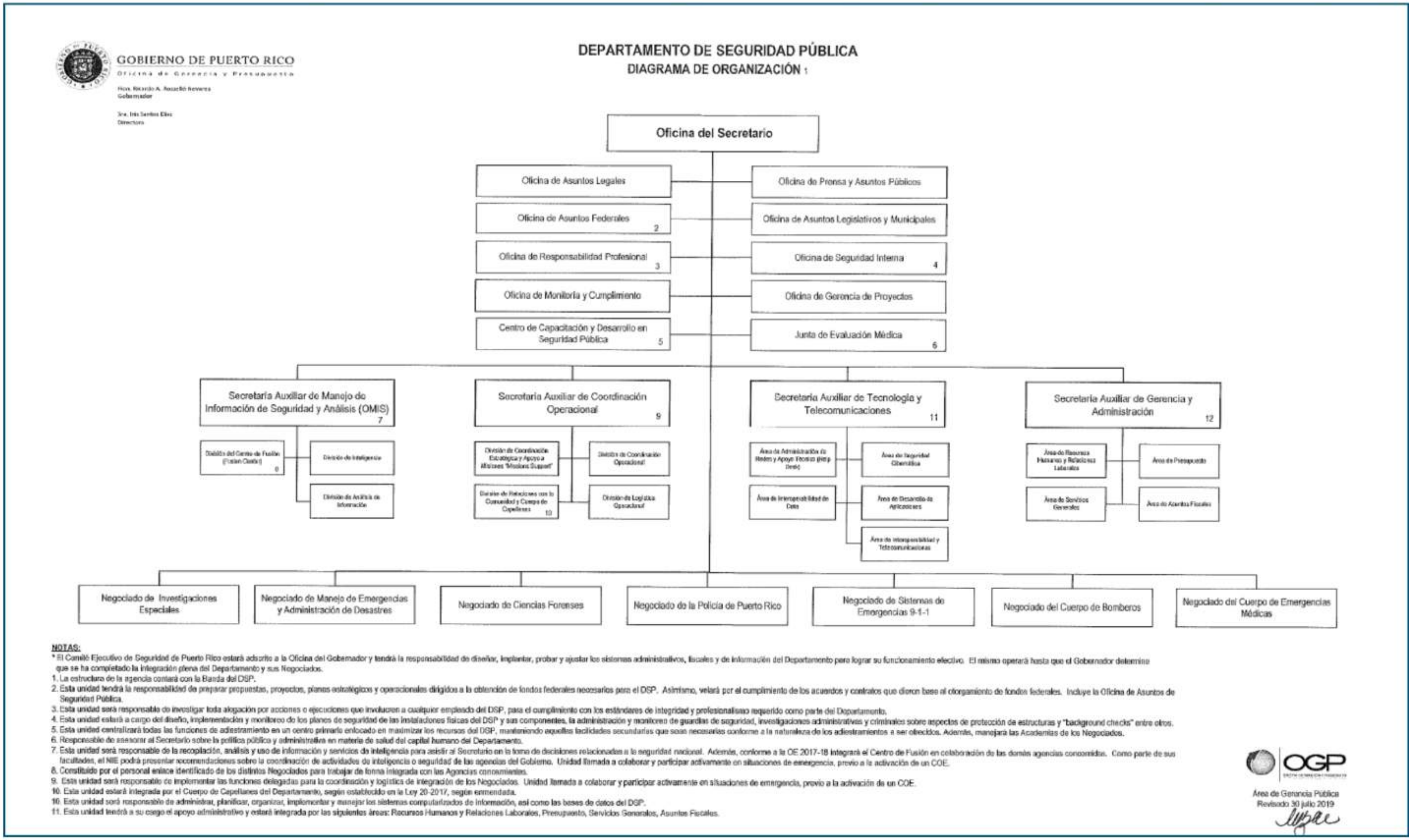
1.4 ADMINISTRATIVE AND OPERATIONAL CONTEXT

PREMB was created in 1976[2] with the fundamental purpose of managing emergencies caused by natural or human hazards, as well as carrying out activities to prevent and mitigate them. Its purpose is comprehensive because activities meet the fundamental needs of an emergency through the four above mentioned phases: preparation (before), mitigation (before and after), response (during), and recovery (after). PREMB's mission is to coordinate all government resources of the Government of Puerto Rico, as well as those of the private sector to provide services quickly and effectively in advance, during, and after emergencies to ensure the protection of life and property of citizens.[3] According to Law No. 20 of April 10, 2017, also known as the Puerto Rico Department of Public Safety Law, the "Puerto Rico Emergency Management Bureau (PREMB) was created under the direct and nondelegable supervision of the Department of Public Safety.[4]The new operational and administrative structure are shown in **Figures 1-2.**

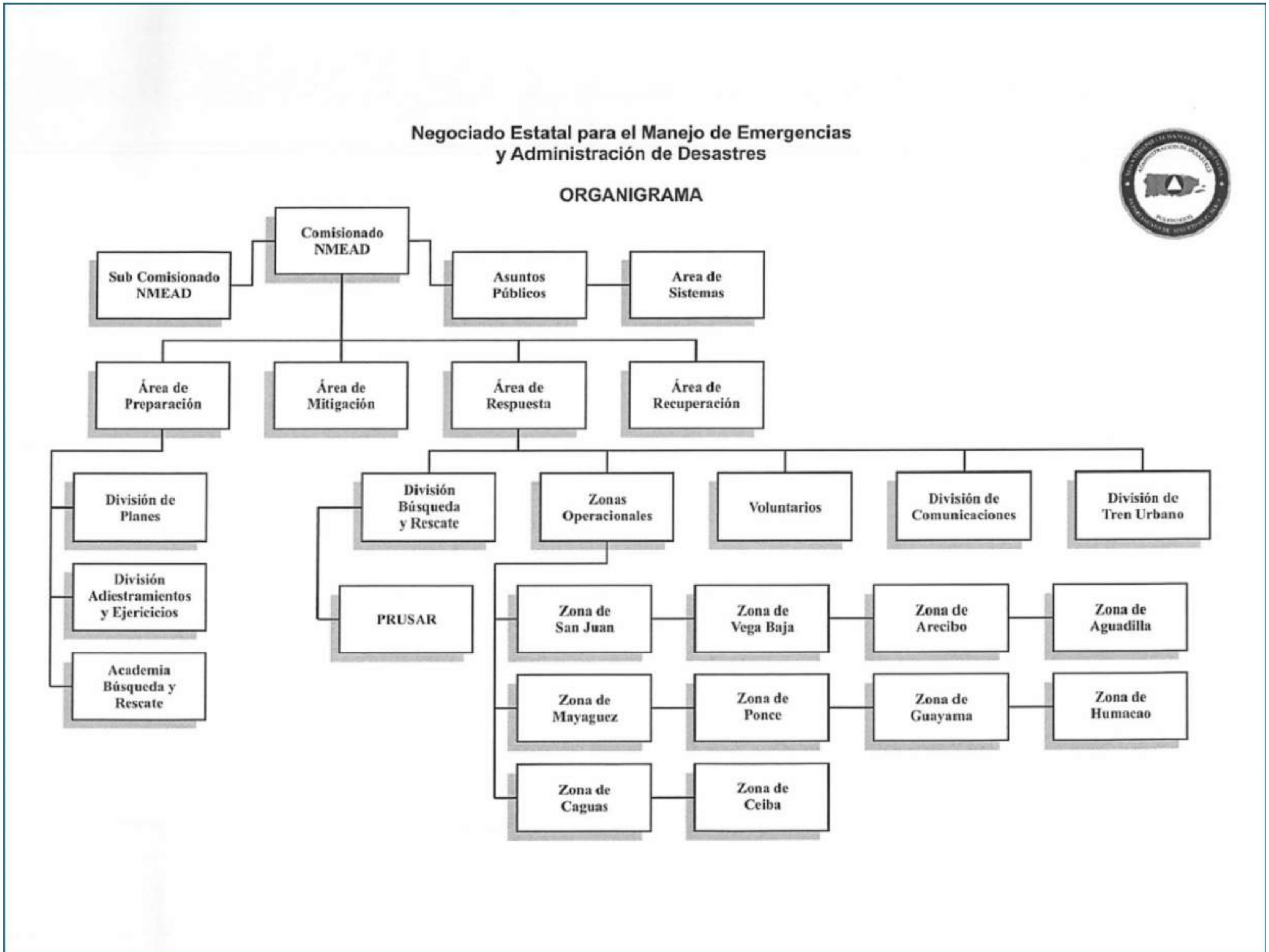
1 OE-2018-045. Executive Order of the Governor of Puerto Rico, Hon. Ricardo Rosselló-Neváres, for the creation of a multi-sectorial working group to mitigate climate change. November 9, 2018.

2 In 1976, the Puerto Rico State Civil Defense Agency was created through Law 22; in 1999, the Law was repealed to give way to Law 211. Law 211 changes the name of Puerto Rico's Civil Defense to the State Agency for Emergency and Disaster
Management, transfers all the resources, functions, powers, and duties that the Civil Defense had and adds new responsibilities. 3 Puerto Rico Emergency Management Bureau (PREMB, by its Spanish acronyms).
http://www.manejodeemergencias.pr.gov/#mision

4 "Article 7 of Law 20-2017, establishes that among the powers of the Director, is the "(o) Develop and maintain a State Emergency Management Plan for all phases of emergency and disaster management, coordinating the actions of state agencies and municipalities in order to provide the earliest possible provision of essential services to meet the needs of our citizens and their restoration as soon as possible; and (r) Respond to the planning program for the mitigation of both natural and technological hazards. To this end, the government representative shall chair the Inter-Agency Committee for State Risk, esthed by Article 11 of this Law. Similarly, he/she will serve as the State Mitigation OfÞcer of the Government of Puerto Rico. This will appoint an Alternate Mitigation OfÞcer to assist in discharging the functions required by this Act."



Figures 1-2. Puerto Rico Homeland Security's Administrative Structure / Puerto Rico Emergency Management Bureau.



Figures 1-2 (continuation). Puerto Rico Homeland Security's Administrative Structure / Puerto Rico Emergency Management Bureau.

The organizational structure of PREMB intends to address the activities required by an emergency or disaster. It is composed of the following offices, areas, and divisions:

1. Office of the Commissioner
2. Office of the Assistant Commissioner
3. Area of Administration
4. General Services Division
5. Division of Human Resources
6. Finance and Budget Division
7. Press and Public Relations Office
8. Office of Public Security (OASP)
9. Mitigation Area
10. Mitigation Projects Section
11. Natural and Technological Hazards Section
12. Recovery Area
13. Individual Assistance Section
14. Recovery Plan Section

1. Estimated Damage Sectio
2. Response Area
3. Operational Areas
4. Search and Rescue Section (PRUSAR)
5. Communications and Emergency 911 Section
6. Urban Train Safety Section
7. State Emergency Operations Center
8. Preparedness Area
9. Planning Section
10. Training and Exercises Section
11. Emergency Management Continuing Education Section
12. Citizen Corps CERT Section
13. Credentialization Section

PREMB offers its services on an island-wide basis through Operational Zones. The ten (10) Zones, organized in three (3) regions, foster rapid response and attention closer to the communities. The distribution of the zones is as follows: Region I (Zones of San Juan, Caguas, Ceiba, and Humacao); Region II (Zones of Aguadilla, Arecibo, and Vega Alta); and Region III (Zones of Guayama, Ponce, and Mayagüez). The following map (Figure 1-3) includes the Zones and the municipalities that make it up.

Figure 1-3: Geographical Distribution of PREMB Regional Offices.

PREMB was initially responsible for managing funds allocated for disaster response and mitigation activities,such as Pre-Disaster Mitigation (PDM) and Flood Mitigation Assistance (FMA). With Act 211, the Office of the Governor's Authorized Representative to FEMA (GAR) has the responsibility to represent the Chief Executive in administering FEMA funds: Public Assistance, Individual Assistance and Hazard Mitigation Assistance, as well as its management. The HMA program covers PDM, FMA, and HGMP funds, according to Section 404 of the Stafford Act. Because of its administrative nature in terms of identifying public funds to match disaster programs, the functions and staffing of the HMA Office have been placed under the Office of Management and Budget.

The creation of COR3's Office responded to an Executive Order[5] that provides a sub-award for DR-PR-4336 (Irma), DR-PR-4339 (Maria), and DR-PR-4473. The COR3 absorbed the Office of the GAR, represented in all states and territories. Thus, the GAR now sits in COR3, and it is the office that manages all mitigation projects under Public Assistance 406, the Hazard Mitigation Grant Program (HMGP), and Pre-Disaster Mitigation (PDM) programs, respectively. Due to administrative constraints (limited availability of resources; leadership changes; redeployment of staff and specialized resources to respond to multiple disasters), COR3 agreed to support PREMB in the coordination of the update of this Plan, under the direction of the State Hazard Mitigation Officer (SHMO).

When a Disaster Declaration is activated, funds are not limited to those for disasters, but to recurrent funds from both the federal and state governments. To this end, the DMA emphasizes the need for close coordination of the planning and implementation of state and local mitigation efforts (municipalities). It is also establishing that a State Mitigation Plan is required to receive federal disaster assistance. This is the main objective of this Plan. To implement the update of the Plan, a Planning Steering Committee was created with the objective of leading the planning process, decision-making and drafting of the Plan. The Committee should be represented by:

- Puerto Rico Emergency Management Bureau (PREMB), the body responsible for coordinating and carrying out the managerial tasks related to the evaluation and preparation of the PRSNHMP.
- Office of the Governor's Authorized Representative (GAR) who oversees the implementation of the agreements between the Federal and State Governments and representing the GPR. Also included is the State Hazard Mitigation Officer (SHMO).

[5] OE-2017-65. Executive Order of the Governor of Puerto Rico, Hon. Ricardo A. Rosselló Nevares, to create the Central Recovery and Reconstruction Office of Puerto Rico. October 23, 2017.

- University of Puerto Rico, Graduate School of Planning, invited by PREMB and COR3 (by collaborative agreement between the parties) to prepare the update of the PRSNHMP.

Table 1-1 presents the current members of the Planning Steering Committee. Other officials with hierarchy in decision-making participate in meetings with this Committee, as necessary.

Table 1-1: 2021 PRSNHMP Planning Steering Committee.

AGENCY	NAME	POSITION
PREMB	Evelyn Moya Ginés	Sub-Commissioner
COR3	Ivelysse Lebrón Duran	State Hazard Mitigation Officer
PREMB	Mauricio Rivera Colón	State Hazard Interagency Mitigation Coordinator
COR3	Sara T. Aponte Meléndez	State Hazard Mitigation Plan Coordinator
PREMB	Luis G. Torres Negrón	Mitigation Technical Support
PREMB	Maritza Sanabria Jarquin	Mitigation Technical Support
PREMB	Frances Dávila Suárez	Mitigation Technical Support

This Committee is also responsible for designing and coordinating the participatory process for the evaluation and updating of the PRSNHMP. In addition, it evaluates the recommendations issued by the other working groups, state, and local government, as well as the recommendations and comments of the citizenry and identifies those that could be accepted. The criteria used to evaluate the recommendations are based on the vulnerability analysis and natural hazard assessment carried out, as well as in the assessment of vulnerability and priorities established by the municipalities in their respective Local Hazard Mitigation Plans.

CHAPTER II

THE PLANNING PROCESS

Courtesy by FEMA

2.1 Planning Process

2.1.1. Planning Update.

As part of the new requirements of the Act, the PRSNHMP must be updated and revised within five years from its last approval in 2016. This revision of 2021 PRSNHMP adopted as a basis 2016 PRSNHMP three basic steps,whose revision and updating work was led by PREMB with the support of COR3 and UPR-EGP.

First, the members of the Planning Steering Committee assist in conducting a comprehensive revision of the document with the assistance of the UPR-EGP. This comprehensive review looks to achieve a full reading and analysis of PRSNHMP 2016 to establish in consensus the level and magnitude of changes that would be required to update each section of the Plan.

UPR-EGP oversaw the evaluation of the available databases describing and analyzing the natural risks affecting Puerto Rico. Based on this assessment, the limitations and strengths of the base information identified complement the data to be used in the presentation of this update. Additional updates information from therisk database includes current scenarios of the effects of climate change manifestations, the impact of Hurricane Maria and Irma, and the 2020 southwestern seismic sequence of Puerto Rico. This update will integrate the pandemic as a risk based on preliminary information available. However, it is recommended that the full analysis and mitigation strategies should be incorporated into the next update.

Second, the mitigation goals, objectives, and actions proposed in the 2016 PRSNHMP were evaluated from two perspectives: (1) the level of compliance, and (2) the opportunity to recommend whether to maintain the mitigation goal, objective or action. All these proposals still constitute one of the most critical parts of this planning document. This process required the participation of the various working groups established to guide the planning process in updating the Plan. The level at which each of the proposals were met provided valuable information on the need to remain or evolve in the Plan and to identify measures and priorities for more effective implementation.

The input provided by all direct and indirect participants in the preparation of the 2016 PRSNHMP was underused. It refers to the data and information that, at this moment, is provided by the working committees, state and federal government agencies, and the inputs, comments, and information that is currently obtained as part of the process of discussion by professionals, interest groups and individual citizens. The recommendations and changes arising from this evaluation approach are under incorporation during the 2021 PRSNHMP update process. A table summarizing the outcome of the evaluation of the Goals and Objectives proposed in the PRSNHMP is shown in **Chapter 6.**

evaluation of the Goals and Objectives proposed in the PRSNHMP is shown in **Chapter 6.**

Third, the federal regulations require specific content for state mitigation plans that includes:
•Documentation of the planning process.
•Risk assessment which provides proposed activities to reduce losses related to identified natural hazards.
•A mitigation strategy that provides the jurisdiction's plan to avoid potential losses identified in the risk assessment.
•A procedure for reviewing the plan; and,
•Documentation demonstrating that the plan was formally adopted by the jurisdiction's governing body.

Once the information is incorporated into the Plan, it is reviewed by FEMA through the State Mitigation Plan Review Tool ("Plan Review Tool"). See Appendix 2-1. The purpose of this regulation checklist is to identify the location of relevant or applicable content in the Plan by twenty (20) elements and to determine if each requirement has been "Met" or "Not Met" to document how the state mitigation plan meets the regulation,according to the State Mitigation Review Guide. If plan requirements are not met, FEMA informs the state of the changes it needs to make in each of the Required Revisions sections.

The Plan Review Tool provides a summary of FEMA's current minimum standards for compliance with DMA 2000and indicates the location where each requirement within this plan is met. These standards are based on FEMA's final rule published in the Federal Register, Part 201 of the CFR. The Steering Committee used the Review Tool Plan as a reference when completing the Plan.

The process used to prepare this plan included twenty (20) The detailed and specific descriptions of each of the steps in the planning process, illustrated in Table 2-1 (next page), resulted in critical work products and results that, collectively, make up the Plan.

With the initial kick-off meeting, celebrated on August 19, 2019, PREMB, COR3, and FEMA agreed on the scope, purpose, and actions to be contained in the Plan. Likewise, the possibility of incorporating the UPR-EGP through a collaborative agreement was discussed, following the example that the Government of the US Virgin Islands implemented with the University of Virgin Islands for the updating of its Mitigation Plan.

PREMB Mitigation Coordinator in support by COR3 State Hazard Mitigation Plan Coordinator was responsible for the development of goals and objectives of the Plan; mitigation strategies; and state and local government mitigation capabilities. By the other hand, the UPR-EGP working groups are assigned to compile the hazard and resource data and to perform the capability assessment taking the 2016 PRSNHMP evaluation as a starting point.

Table 2-1. ***Planning Tasks.***

	TASK	DUTIES	EXPECTED	RESPONSIBILITY	COMMENTS
1	Planning Support	• Kick Off Meeting (08.19.2019 • Integrate a Professional Planner in COR3 Hazard Mitigation Team.	Nov/2019	SHMO	Combined support of S. Aponte from COR3 Strategy Group
2	Developing Work plan	• Define COR3 HMGP Support to PREMB. • Local Coordinator functions. • Additional Resources identification.	Feb. 2020	COR3/PREMB	Discussed with FEMA R2. Completed;
3	Collaborative Agreements	• Support from UPR-EGP; voluntary students. • Development of graduate course to offer between Aug-Dec 2020.	Sept. 2020	COR3-UPR-PREMB	Support from UPR-EGP Voluntary students for drafting Chapters 1, 2, 4 and 5; MOU under final revision of UPR.
4	Committee Meeting	• Planning Steering Committee (08.14.2020/09.11.2020/09.30.2020/11.16.2020) • Interagency Committee Call (09.25)	Mar-Dec 2020	PREMB	Ongoing; with the support of COR3
5	Data Collection for Hazard and Impacts	• Compilation of data on hazards and resources at risk.	August 2020	COR3	Completed
6	Capability Assessment	• Assess capability of existing systems to execute mitigation activities.	October 2020	COR3-UPR	Completed. Ch. 4 & 5 drafted between Apr-Jun 2020; Pending to submit to FEMA for courtesy review in 12.18.2020
7	Stakeholder Engagement	• Presentation to Academia, Professional Organizations, NGO's and community representatives.	October 2020	PREMB	Completed. Meeting was held on 10.22.2020
8	Municipal Engagement	• Present the Plan Process to Asociación and Federación de Alcaldes Representatives	Sept 2020	PREMB	Mayors' Federation and Association were invited to participate in the Interagency Committee meeting on 09.25
9	Vulnerability Assessment & Data Collection	• Complete database of resources at risk to priority hazards. • Perform detailed vulnerability assessments for priority hazards	October 2020	UPR-EGP	Completed. Pending delivery on Dec. 23, 2020

	TASK	DUTIES	EXPECTED	RESPONSIBILITY	COMMENTS
10	Hazard/Vulnerability Prioritization	• Identify data gaps. • Prioritize hazards • Identify who to fill gaps. • Demonstrate vulnerability assessment methodology.	Nov/2020	UPR-EGP COR3	Completed. Pending delivery on Dec. 23, 2020
11	Mitigation Opportunity Analysis and Plan Formulation	• Mitigation strategies, plans, policies and programmes.	Dec.2020/ Jan.2021	PREMB-COR3	In progress, pending comple
12	Public Consultation	• Series of consultations (community meetings, academia, interest groups, NGO's)	TBD	COR3/PREMB	See Task #7ted on 01.15.2021
13	Review of Final Version	• PReview plan introduction, goals and objectives, hazard identification, hazard prioritization, preliminary capability assessment analysis, preliminary identification of mitigation opportunities and Appendices. • Implementation and Monitoring	Feb.2021	COR3/PREMB	Pending Expected on 01.31.2021
14	Final Plan submission to FEMA		Feb 20, 2021		
15	FEMA 45 days review		Apr 6, 2021 (Expected)		
16	State Government edits, resubmission, and review to FEMA		May 6, 2021 (Expected)	COR3/PREMB	
17	Spanish Translation		Jan-Jun 2021 (Expected)	PREMB	
18	Plan Approved Pending Adoption	• Letter from FEMA	Jul 23, 2021 (Expected)	FEMA-HM	
19	Adoption Letter	• Signed by Puerto Rico Governor	Aug 6, 2021 (Expected)	PREMB	
20	Final Plan Approval	• Letter form FEMA	Aug20, 2021 (Expected)	FEMA-HM/PREMB	

The activities and information needed to update the PRSNHMP chapters were identified and organized as follows:

- Chapter 1 - Introduction and Background.
- Chapter 2 – Planning Process.
- Chapter 3 - Hazard Identification and Risk Assessment.
- Chapter 4 - Assessing State Government Capabilities.
- Chapter 5 - Assessing Local Government Capacities.
- Chapter 6 - Mitigation Strategies.
- Chapter 7 - Plan Review and Monitoring.
- Chapter 8 - Adoption and Approval of the Plan.

2.1.2. Planning Schedule.

As part of the process of the review development, a work plan was developed that aligned the timeline agreed with the FEMA-Hazard Mitigation Group based on the following criteria: 1) Roles and Tasks (suggested), 2)Timeline, 3) Deliverables (according to the State Mitigation Review Guide) and 4) Additional resources. This part summarizes the activities developed for the update process. It outlined twenty (20) significant steps throughout approximately twenty-four (24) months, with specific duties, time allocated, and teams and/or individual responsible for execution within a period ranging from August 2019 to August 2021.

The process of updating the 2021 PRSNHMP is carried out on various levels, as shown in **Appendix 2-2**.

2.1.3. Diagnosis.

The public policy of PREMB is to protect the inhabitants of Puerto Rico in emergency situations or disasters that affect the Island and to provide in the most rapid and effective way the necessary assistance for the protection before, during and after these, thus ensuring the protection of life and property. The implementation of its public policy is the main strength of PREMB, which is supported by various components and actions, as follows:

- Extensive and proven organization throughout the Island and its communities.
- Qualified and properly trained personnel, as well as countless volunteer groups throughout the Island.
- Adequate management of human resources, technical and fiscal resources.
- High backrest and support of the citizenship in the agency’s functions.
- Wide experience in emergency management at the local and State levels.

However, it is important to mention that the current fiscal situation of the GPR may limit the ability of PREMB to implement mitigation strategies and activities, as well as its operational activities. Some of the limitations that PREMB may face, taking into consideration the fiscal crisis in Puerto Rico, are:

- Budget reductions in several of its departments and units.
- Reduction in human resources and training, operation, and maintenance activities.
- Physical plant and equipment impairment due to budget reductions.
- Other effects caused by unavailability of funds.

PREMB's proven strengths show it can meet the challenges it may face in the face of the fiscal crisis. Furthermore, the 2021 PRSNHMP approval is a key tool for PREMB as it presents mitigation strategies in addition to assessing the impact of potential natural hazards. Following the mechanisms of strategic planning, the following infographic summarizes the strengths, weaknesses, opportunities, and threats of the agency.

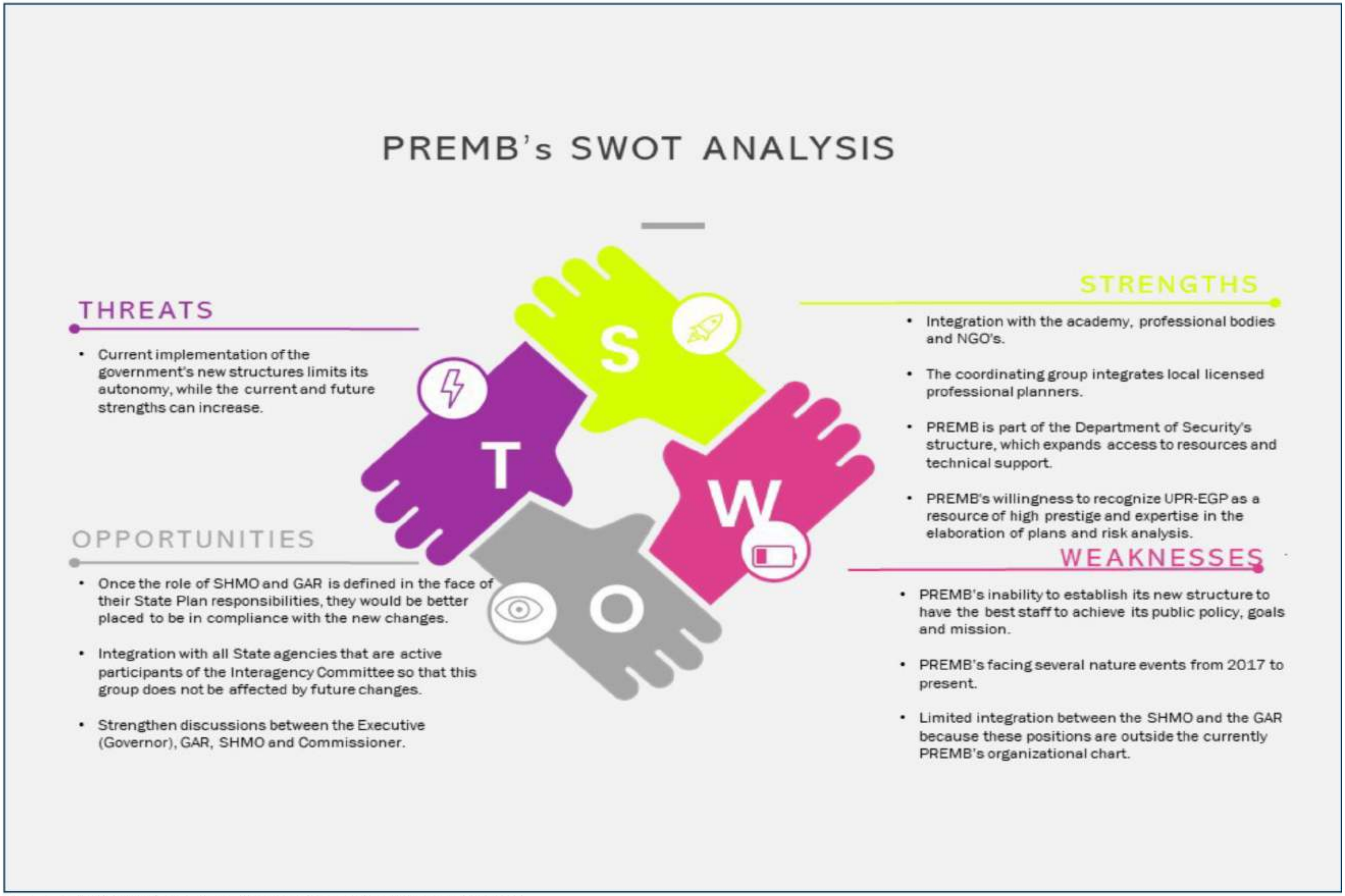


Figure 2-1: SWOT Analysis for Current Planning Update Process.

2.1.4. Coordination with Stakeholders.

Coordination with State and Federal Agencies.

One of the challenges in the process of updating 2021 PRSNHMP is to establish, within the complex scenario currently managed by the GPR, mechanisms facilitating the participation of as many government agencies as possible in the various components of the Plan. The preparation of the PRSNHMP is not defined as the product of a particular agency, such as PREMB, but rather as the focal point for coordinating all the efforts and activities required for the preparation of the PRSNHMP. This participation was obtained through the following mechanisms: telephone calls, electronic communications and letters requesting information, and inviting agencies to participate in working committees, presentations, and technical discussions.

This coordination began with a Kick-Off meeting on August 19, 2019, with the participation of PREMB, COR3 and FEMA, where the intention of the State Hazard Mitigation Plan was discussed, mainly the following points:

- Clarification of the importance of having an updated Plan in terms of the availability of obligated federal funds for current and future disasters.
- PREMB and SHMO agreed to do a short review to the current plan and apply for a comprehensive review of the Plan under the HMGP.
- PREMA / SHMO are considering the building capacity of in-house workforce and students instead of contracting.
- Planning Process. A sector review process was recommended to look at the hazards and mitigation strategies. Steering committee will oversee that all the sectors talk to each other's.
- Although public engagement is not a requirement, it was recommended to have it.
- Recommended types of working committees (Steering, Interagency, and Technical Committees).
- High Hazard Potential Dam Its not required, its optional. If GPR would interest apply to HHPD grants, it is required to address dam risk to request funding through FEMA.
- Local Mitigation Plans need to be contemplated in the update.
- Approach of the impact of climate change in future risks needs to be part of the Plan.

Attendance sheet as well as the meeting notes of the Kick-Off Meeting are part of **Appendix 2-3**.

One of the challenges in the process of updating the PRSNHMP 2021 was to establish, within the complex scenario currently managed by the GPR, mechanisms that would facilitate the participation of the greatest possible number of government and non-government agencies within the various components of the Plan.

This participation was achieved through phone calls, electronic communications and letters requesting information,and inviting agencies to participate in working committees, presentations, and technical discussions. See **Appendix 2-4.**

The Planning Steering Committee served as the central focus throughout the process. It is responsible for evaluating the recommendations and comments issued by the working committees and at public meetings to be incorporated into the various sections of the Plan, based on the Law's requirements and the priorities of Puerto Rico. As noted above, the development of the 2021 PRSNHMP used a strategic and participatory planning approach involving the coordination of the participation of state agencies, federal agencies, and representatives of the private and academic sectors, among others. The involvement of different committees in the PRSNHMP is described below.

Interagency Committee for the Mitigation of Natural and Technological Hazards.

Article 11 of Law 211 of August 2, 1999, and the Executive Order OE-2001-26 constituted the Interagency Committee for the Mitigation of Natural and Technological Hazards (ICMNTH) for the preparation of the PRSNHMP. It comprises representatives of (16) State agencies and private organizations and is responsible for reviewing the goals, objectives, and mitigation actions, as same as set out in the 2016 PRSNHMP). Appendix 2-5 includes a list of the agencies and additional organizations that were part of the ICMNTH, for a total of (20)twenty.

The strategy used in the 2016 PRSNHMP revision of incorporating working committees with responsibilities at different stages of development remained in this revision. Due to simultaneous multi-disasters response) In this update and due to multi-disaster response, the committees in charge of the 2021 PRSNHMP revision and update process are Planning Steering Committee, and the Interagency Committee for Natural and Technological Risk Mitigation.

All working committees involved in the development of the PRSNHMP will report to the Planning Steering Committee. The integration of the interagency committees is essential as their representatives serve as intermediaries, between their respective agencies and the Steering Committee, in the process of collecting the information and statistical data necessary for the various stages of PRSNHMP development.

The ICMNTH focused on vulnerabilities and mitigation strategies for specific hazards that were worked on in this Plan. ICMNTH participated cooperatively and in good faith to maintain a FEMA-approved PRSNHMP as required to benefit the entire GPR. ICMNTH participation was based on the 2016 PRSNHMP update, validation of risk analyses, development of goals and objectives, and mitigation strategies. Invitations to participate as part of the ICMNTH were originated by the Mitigation Coordinator and members of the Planning Steering Committee through emails and phone calls. Its first meeting was held on September 25, 2020, with the involvement of twenty-eight (28) representatives from fifteen (15) agencies. See **Appendix 2-6.**

As part of the actions taken after September 25, 2020's meeting, the materials presented were circulated to all participants, including those who did not have the opportunity to participate. The Steering Committee followed up with participants for two weeks after the first meeting to clarify questions about the planning process and receive the requested information on critical infrastructure in their agencies and descriptions of the projects and mitigation efforts that are part of their respective plans. In turn, Committee members communicated routinely and were kept informed through an e-mail distribution list.

Technical Committee.

Contrary to the 2016 PRSNHMP, this update had a Technical Committee composed of representatives of academic entities and specialized institutions to contribute to the development of the 2021 PRSNHMP. Unlike the 2016 PRSNHMP, this update had a Technical Committee consisting of representatives from educational entities and technological institutions to contribute to the development of the 2021 PRSNHMP. Executive Order 2001-26 empowers the PREMB State Director, as Chair of the Interagency Mitigation Committee, to establish technical and working committees as he or she deems necessary to fulfill the responsibilities assigned to the Interagency Mitigation Committee.

For this occasion, the following organizations were integrated into the 2021 Plan update process. Also, community-based organizations have been key in providing support to the government both in the responseand in the recovery process, it was therefore pertinent to integrate them into this effort. See **Appendix 2-7.**

With their knowledge and particular studies, the objective was to offer technical support to the UPR-EGP in providing scientific knowledge, technical reports, and digitized geographic archives that would complement the validation of results and recommendations aimed at developing mitigation strategies. In turn, the Committee has subject matters experts for each risk examined. The analyses and evaluations have rigorous and tempered support on the natural events' impact during the period covered by this Plan.

Due to the physical restrictions required by COVID-19, this meeting was held virtually on October 22, 2020. The purpose was to introduce the components of the PRSNHMP and opened the space for other stakeholders to be part of the development of the Plan through specific request of data, technical in formation, and mitigation activities. This group met in one (1) occasion in addition to multiple individual consultations through emails and telephone communications. **See Appendix 2-8.**

Table 2-3 (next page) presents the progress of the tasks that have been carried out and what remains to be completed, in relation to the work plan presented in Table 2-2.

Dam Safety Officer.

The Dam Safety Officer is the Chief of the Irrigation Dams and Reservoirs Division of the Puerto Rico Electric Power Authority (PREPA). By 2016, the DSO recommended that the State Mitigation Plan should take dam breaks into consideration in the flood risk analysis and thus access funds through the High Hazard Potential Dam Grant Program (HHPD).

For the update of this Plan, the DSO has actively collaborated in all stages of the plan (planning process, risk analyses, mitigation strategies and funding). The DSO is part of the Interagency Committee for the Mitigation of Natural and Technological Hazards (ICMNTH) as well as participating in regular meetings and discussions of the Technical Committee. It also advised the Steering Committee on matters brought to its attention and provided technical documentation such as studies, existing analyses, methodology and recommendations on the dams in Puerto Rico that are categorized as high risk within the planning process.

For the risk analysis, the DSO provided the UPR-GEP team with scientific literature and case studies that complemented the risk analysis developed for this Plan. Their participation was not limited to sharing technical information but to advising the team in charge of working on the risk of flooding associated with dam failures.

COR3 shared with him the FY20 Rehabilitation of High Hazard Potential Dams (HHPD) Notice of Funding Opportunity (NOFO), which includes the requirements and new planning considerations for accessing these funds, an effort that the DSO and his team are currently developing.

Table 2-3: Stakeholders Participation and Coordination for the Update of 2021

DATES OF ACTIVITIES	TASK
20-ago-19	Kick-off Meeting: Discuss strategies and present the Work Plan for the elaboration of the PRSNHMP. Representatives of the following sectors participated in this meeting: Emergency management, Economic development, Land use and development, Housing, Health and social services, Infrastructure, and Natural and cultural resources.
13-nov-2019	Meeting between SHMO, PREMB and FEMA to discuss proposed working Schedule.
18-nov-2019	Designation of State Reviewer in COR3 Hazard Mitigation Team to provide planning support to PREMB.
27-dec-2019	Follow up meeting with SHMO, PREMB Commissioner and COR3 at this meeting, the itinerary, the responsibilities of each of the agencies (PREMB, COR3 and FEMA) and necessary resources were discussed. PREMB Commissioner indicated that they had some of the necessary resources. SHMO recommended to the Commissioner that consideration be given to bringing in resources from the UPR Graduate School of Planning to support PREMB.
24-Feb-2020	Presentation and discussion with FEMA R-2 about the Workplan; define COR3 HMGP Support to PREMB: local coordinator functions and identification of additional resources.
9-Jan-2020	Support from UPR-EGP; voluntary students: Presentation of the PRSNHMP to UPR Graduate School of Planning students; development of graduate course to offer between Aug-Dec 2020.
24-Feb-2020	Meeting with PREMB Commissioner to discuss and approve tentative Workplan.
25-feb-2020	Meeting with UPR Graduate School of Planning Director, Faculty and FEMA R2 Mitigation Planning Lead to establish tasks for risk analysis, preparation of vulnerability maps and other analyses using Geographic Information Systems (GIS). Facilitate a collaborative agreement for the risk assessments and mitigation strategies.
Mar-May 2020	Data Collection for Hazard and Impacts: Compilation of data on hazards and resources at risk by COR3.
15-apr-2020	Submission to FEMA of First Deliverable: Introduction and Chapter I
Apr-Jun-2020	Assess capability of existing systems to execute mitigation activities: Working on recommendations for Chapter 1; Collection of Local (Municipal) Mitigation Plans to review and produce a summary that includes: defined goals and objectives, hazards to which they are exposed, potential losses associated with each risk and mitigation strategies or projects. The summary of the Municipal Mitigation Plans should be incorporated into Chapter 5: Mitigation Capacity and Local Coordination
15-Jun-2020	Submission to FEMA of Second Deliverable: Chapter I (revised version), and Chapters IV and V.
Aug-Sept 2020	Planning Steering Committee meetings (08.14; 09.11) and Interagency Committee Call.; Drafting MOU between PREMA-UPR/EGP
15-sept-2020	Send official letters to state and federal agencies that are relevant to the PRSNHMP explaining the objectives of the Plan and requesting information on studies, projects and/or activities to mitigate natural hazards in Puerto Rico. In addition, they are asked for databases that could be relevant to the inventory of natural hazards
Sept-Oct 2020	Municipal and Stakeholder Engagement: Presentation to members of the Mitigation Committee of PRSNHMP objectives and promote interagency participation in the revision process (1st Meeting 09.25.2020). Mayors' MUNIC and Association were invited to participate in the Interagency Committee meeting on 09.25.2020.
15-oct-2020	Presentation to Academia, Professional Organizations, NGO’s, and community representatives.

DATES OF ACTIVITIES	TASK
Aug-Nov 2020	Hazard/Vulnerability Assessment & Data Collection: Complete database of resources at risk to priority hazards; Perform detailed vulnerability assessments for hazards; Identify data gaps; Prioritize hazards; Identify who to fill gaps; demonstrate vulnerability assessment methodology.
Nov-Dec. 2020	Mitigation Opportunity Analysis and Plan Formulation: Mitigation strategies, plans, policies and programmes
Dec. 2020	Public Participation: Stakeholders Series of presentation (2nd meeting).
Jan-Feb 2021	Review of Final Version: Review plan introduction, goals and objectives, hazard identification, hazard prioritization, preliminary capability assessment analysis, initial identification of mitigation opportunities and Appendices; Implementation and Monitoring
February 20, 2021 -(Expected)	Final Plan submission to FEMA.
April 6, 2021 - (Expected)	FEMA 45 days review.
May 6, 2021 - (Expected)	State Government edits, resubmission, and review to FEMA.
Jan-Jun 2021 - (Expected)	Spanish Translation (Subject to previous agreement between PREMB-FEMA).
July 23, 2021 - (Expected)	Plan Approved Pending Adoption: Letter from FEMA.
August 6, 2021 - (Expected)	Adoption Letter: Signed by Puerto Rico Governor.
August 20, 2021 - (Expected)	Final Plan Approval Letter from FEMA.

Federal Agencies

As part of the PRSNHMP planning process, Federal Agencies (OFA) that are relevant to the objectives of the Plan are consulted to enable their participation in the planning process and to request information on natural hazards, vulnerability studies and the implementation or future projects of mitigation activities. The criteria used to select federal agencies are based on their relevance to the planning and/or financing of mitigation activities and the management of natural disasters. Federal agencies consulted were the FEMA, NOAA (National Weather Service), USGS, U.S. Environmental Protection Agency (EPA), among others.

Environmental Protection Agency.

Since Hurricanes Irma and Maria occurred in 2017, the EPA has been working in collaboration with FEMA, the GPR, local authorities, non-governmental organizations (NGOs) and communities to ensure that all disaster related response and recovery activities result in a more resilient Puerto Rico and a safer, more sustainable society. To continue these efforts, EPA has agreed to collaborate the PREMB and COR3 in the revision of the 2016 PRSNHMP in the following ways. First, EPA will collaborate with PREMB and COR3 by reviewing and analyzing the National Mitigation Investment Strategy (NMIS) to offer recommendations for ways in which the NMIS could be incorporated into mitigation strategies for each of these four specific risks: 1) Flooding 2) Landslides 3) Strong Winds, and 4) Liquefaction.

After PREMB and COR3 has had a chance to review and incorporate the EPA recommendations, EPA will review the draft mitigation strategies for each risk to determine if the NMIS has been adequately incorporated throughout. Following the review, EPA will provide feedback regarding any edits that should be considered by PREMB and COR3. Lastly, EPA will provide additional mitigation strategies that EPA has identified as critical for mitigating risk. Through this collaboration, EPA would be assisting in developing strategies for the revised state hazard mitigation plan that will help mitigate hazards resulting from disasters and will lead to a more sustainable, resilient Puerto Rico.

2.1.5. Public Involvement.

Local State (Municipal) Participation.

To guide the updating of the Plan, PREMB convened both the Federation of Mayors and the Association of Mayors to form part of the Interagency Committee for the Mitigation of Natural Hazards. The Federation of Mayor's groups' municipalities affiliated with the New Progressive Party (PNP) and the Association of Mayor's groups' municipalities affiliated with the Popular Democratic Party (PPD). Both entities' primary mission is to link the Municipalities, the State Government, the Legislative Assembly, Government Agencies, and Federal Agencies.

Among their functions is to achieve better and more efficient coordination between these bodies, to stipulate and advocate for greater authority and/or municipal powers, as is the case with Law No. 81, approved on August 30, 1991, which is known as the "Ley de Municipios Autónomos". This law expands the powers and faculties of all municipalities and grants them, for the first time, fiscal autonomy. Another of its functions is to advise its members individually and collectively,

In that direction, both organisms were approached to integrate municipal and community representation into the team formed by representatives of various government instrumentalities and other key actors as critical members in the planning process. They were also introduced to aspects of the Plan's preparation. They provided valuable input into updating the document since its members had specialized knowledge in each of their fields and responsible for implementing the mitigation strategies developed during the planning process. In this way, the community interests that were embraced in their local mitigation plans were supported. In addition to the information requested, the participation of the municipalities consisted of offering their availability for:

- Provide information that would help complete the Capability Assessment section of the Plan (Local Government) and assistance in providing relevant documentation related to mitigation or risk for review and incorporation into the Plan.
- Participate in discussions leading to the development of mitigation strategies, including the design and adoption of regional goal statements.
- Support the design of appropriate mitigation actions for incorporation into the Mitigation Action Plan.
- Provide timely feedback on all results of the analyses required by the Plan, if necessary.

The results of these efforts are reported in **Chapter 5 "Mitigation Capabilities of Local Government",** where the mitigation strategies contained in their respective plans were collected and analyzed for incorporation into state-level strategies.

Citizenship and other groups of interest.

At the kick-off meeting on August 19, 2019, it was agreed that public engagement is not a requirement, however it is a recommendation to take into consideration for the next Plan update. In this sense, and to facilitate the opportunity to receive input and recommendations on issues related to natural hazards affecting the communities, a call was made to community organizations to participate in an orientation on the process of updating the Plan.

The updating of this Plan also counts on the collaboration of two community-based non-governmental organizations whose efforts respond to the design of strategies for the mitigation of risks associated with water resource management: Fundación Comunitaria de Puerto Rico (FCPR) and the San Juan Bay Estuary Watershed Program (SJBEWP).

FCPR, a non-profit organization, designs and implements programs based on the needs of communities. Since Hurricane Maria (September 2017), the Foundation has supported projects for equitable and sustainable access to clean water, renewable energy, housing, community economic development, and education. In May 2020, FEMA approved $625,000 for the first phase of a project under the Hazard Mitigation Grant Program (HMGP). It consists of providing a solar energy generation system and systems to 242 rural communities in forty-four municipalities that operate alternative water systems to Puerto Rico Aqueducts and Sewer Authority.

On the other hand, SJBEWP, a non-profit organization that works to protect this ecosystem, in the eight metropolitan municipalities that make it up: Bayamón, Carolina, Cataño, Guaynabo, Loíza, San Juan, Toa Baja, and Trujillo Alto, has provided valuable resources to the inhabitants of the region. However, the needs of a growing population have led to the exploitation of the system's natural resources and the degradation and destruction of many of the estuary system's components.

To address these needs, the SJBEWP establishes a cohesive mitigation policy for the basin, the Hazard Mitigation Plan for the San Juan Bay Estuary Watershed, to take advantage of the unprecedented level of funding available for implementation of reconstruction and mitigation projects. The SJBEWP program will follow FEMA requirements for local mitigation plans to facilitate access to Federal recovery and mitigation funds.

The participation of specialized academic and institutional entities is requested to contribute their knowledge and studies to the various activities required to prepare the PRSNHMP. The aim is for the institutions to provide technical information, related studies, and geographic electronic archives for analysis and use in the development of the PRSNHMP. The invitation is made through official letters explaining the objectives of the PRSNHMP and requesting its participation.

2.1.6 Integration with Other Planning Process.

Taking into consideration and integrating other processes of State and municipal planning that exist in the country to the updating of the PRSNHMP is important because many of these processes have an impact on the mitigation of natural hazards. Some of these efforts, processes or laws are discussed below.

Mitigation Plans and Activities of the Interagency Hazard Mitigation Committee Agencies

Law 211 sets mitigation targets to be followed by all state agencies. These mitigation targets include each Committee Agency coordinating and preparing mitigation plans and activities for their respective agencies for the purpose of protecting the lives of their employees and visitors, and their facilities. In addition, agencies' mitigation plans should be aimed at ensuring the continuity of the services they provide or the restoration of those services as soon as possible after an emergency event.

Puerto Rico Planning Board

The Puerto Rico Planning Board (PRPB) is the agency responsible for managing the integrated, economic, social, and physical development of Puerto Rico. Its Organic Law establishes that the PRPB has the ministerial duty to prepare and adopt regulations and maps aimed at guiding an orderly planning process and making decisions on land uses; actions that directly impact the mitigation of natural hazards.

Permits Management Office

Functions of the Permits Management Office (OGPe) have a direct impact on risk mitigation as it is responsible for assessing and granting or denying permits that were previously under the jurisdiction of the Regulations and Permits Administration. OGPe shall determine the environmental compliance of any action subject to an environmental impact analysis under Law No. 416 of September 22, 2004, as amended, known as "Puerto Rico's Environmental Public Policy Law"; and after entering into interagency agreements, issue permits, certificates, licenses, or government documents required for purposes of construction and land use, and for conducting or operating business.

Puerto Rico Land Use Plan

The Puerto Rico Land Use Plan (PUT in Spanish) is a fundamental tool for land use planning and hazard mitigation. The PUT, in force since November 19, 2015, formulates goals, objectives and strategies to guide the country's development. One of the goals of the PUT that reflect its impact on hazard mitigation is to preserve and protect natural, archaeological, or agricultural resources, rural soils and environmentally sensitive from the adverse effects of uncontrolled construction.

In addition, the PUT establishes guidelines for climate change mitigation and adaptation that are taken into consideration in the 2016 PRSNHMP review.

Municipal Territorial Planning Plans

The Land Management Plans (POT in Spanish) drawn up by the municipalities are directly related to the mitigation of natural hazards since they provide mechanisms for municipalities to regulate land use and manage urban and rural development. In addition, it provides the instruments to implement the plans and regulations that it understands are necessary to serve its territory. Planning of the territory is directly related to risk mitigation, as it offers the tools to control development in areas most at risk and to promote it in those areas where the risk is least.

Local Hazard Mitigation Plans

A crucial part of the PRSNHMP review is the integration of the Natural Hazard Mitigation Plans that the 78 municipalities of Puerto Rico must develop to identify the hazards that directly affect their territory and identify actions to mitigate them.

The integration of these plans was carried out through the participation of State Reviewer, responsible for fulfilling the requirements of the 44 CFR § 201.6 (d) Plan Review as well as executing the COR3 HMGP review process of local mitigation plans. This function was assigned to COR3 State Planner who participated in the initial meetings of the local plans (between municipality, PRPB and contractor), as well as the initial review and issue recommendations prior to sending them to FEMA for final review and approval.

As of July 30,2021,and as part of the PRSNHMP update, 68 Local Plans are current and 10 are currently under revision or under development. [11].

2.2 MISSION, VISION, GOALS AND OBJECTIVES

The Mission, Vision, Goals and Planning Objectives of the 2021 PRSNHMP is based on the general concept of encouraging the State and Local government to identify the natural hazards that impact them, outline the actions and activities that are conducive to reducing the losses that these hazards may cause, and establish a coordinated process to implement the 2021 PRSNHMP, maximizing available resources. The mission presents the purpose of this Plan and the results it seeks to achieve. The Vision presents how Puerto Rico should be in the future, which it hopes to achieve in the long term, once the 2021 PRSNHMP is in its implementation phase. Overall, the mission, vision, goals and planning

[11] Monthly Hazard Mitigation Local Planning Report. FEMA. July 30,2021.

objectives proposed in the 2016 PRSNHMP have remained intact, as they guided the original preparation of the Plan, as well as its revisions.

Mission.

The 2021 PRSNHMP will make the Island of Puerto Rico minimize in the long term the negative impact of identified natural hazards, including the new challenges posed by climate change phenomena. It will achieve this through an integrated public mitigation policy between the State and Local government and efficient management of mitigation activities designed in the Plan.

Vision.

Puerto Rico's territory would be an environmentally safe place for its inhabitants, as it would minimize the loss of life and property caused by natural hazards. It will institutionalize a public mitigation policy aimed at reducing the harmful effects caused by natural hazards through its plans, laws, ordinances, and regulations.

Goals and Objectives.

Goal 1: Coordinate a process of public participation in the revision and updating of the Plan that includes state agencies, federal agencies, and interest groups, with the aim of integrating the planning efforts of each group into the Plan.

Objectives:

- Establish working committees that integrate the participation of the different sectors:state agencies, federal agencies, and interest groups.
- Integrate mitigation efforts and/or activities, whether State, municipal and/or federal, into the Plan.

Goal 2: Examine the vulnerability analysis and natural hazard assessment of the territory of Puerto Rico, considering the updated information and available technical and economic resources, to update the mitigation strategy.

Objectives:

- Identify new information on potential, significant and non-significant natural hazards.
- Assess the vulnerability of critical State facilities and their geographical distribution according to the identification of areas prone to natural hazards.
- Estimate the potential losses of critical state facilities and their geographical distribution according to the identification of areas prone to natural hazards.

Goal 3: Design a mitigation strategy aimed at minimizing the negative impact of identified natural hazards.

Objectives:

- Base the mitigation strategy on the outcome of the studies, vulnerability assessmentsand natural hazard analyses conducted.
- Incorporate the vulnerability analyses and mitigation strategies outlined in the Local Mitigation Plans into the review and updating of the strategy established in the 2021 PRSNHMP.

Goal 4: Design effective coordination mechanisms to integrate the implementation of mitigation activities by the State and Local governments through a specific strategy.

Objectives:

- Define the criteria that will prioritize the allocation of funds and technical assistance to municipalities, basing them on the results of vulnerability analysis and assessment of natural hazards.

Goal 5: Review and update the ongoing evaluation process of the Plan.

Objectives:

- Review and update the monitoring system for the mitigation activities to be implemented.
- Review and update the system established for the ongoing review and updating of the Plan.

Goal 6: Reducing the loss of life and property from natural hazards.

2.3 ADOPTION AND COMPLIANCE WITH STATUTES OF LAW

The 2021 PRSNHMP review and update will be adopted by the GPR on August 2021 (expected date) by Executive Order, which sets out the State's commitment to the implementation and implementation of the objectives, proposed goals and activities. This Executive Order will be presented at the beginning of the Plan. In addition to the formal adoption of the Plan, the State, in compliance with the regulations in force, will certifies that:

- The 2021 PRSNHMP will be develop and revise according to the requirements established by the federal law "Disaster Mitigation Act of 2000 (DMA 2000) and in compliance with the State Mitigation Plan Review Guide-2016.
- As part of the implementation of the Plan, the State recognizes and certifies strict compliance with the applicable federal regulations and statutes to receive financing grants as described in 44 CFR 13.11(c)

- In compliance with 44 CFR 13.11(d), the 2021 PRSNHMP will be amended in the event of the establishment of new federal regulations or statutes, changes in applicable state laws, as well as relevant changes in the organization, public policy, or operation of the agency in charge of the implementation of the Plan. Any amendments made during the life of the Plan will be added as an annex to the original Plan and subsequently incorporated into the relevant sections when the next formal revision of the Plan is carried out, as required by Section 201.4(d) of the Law.

The complete process for adoption and approval of the Plan is described in **Chapter 8.**

CHAPTER III

HAZARD AND RISKS ASSESSMENT

Courtesy by FEMA

The purpose of the Hazard Identification and Risk Assessment is to identify natural hazards and to evaluate the risk they pose to the Government of Puerto Rico, the health and safety of its citizens, property, and economy. A vulnerability and risk assessment are a decision support tool for determining the need for and prioritization of mitigation measures to protect assets, processes, and people. While it is financially unfeasible to reduce risk from every hazard event, vulnerability and risk assessments can help ensure that the available resources and actions taken are justified and implemented based on the threat, vulnerability, and risk.

Hazard identification and the assessment of associated risks is a shared responsibility between the state and local governments. Both the state and local governments assess the risks from hazards as part of their respective planning processes. While local governments focus on the hazards, vulnerabilities, and risks on a local or regional scale, the state focus remains on the regional and statewide implications of hazards.

The Hazard Identification and Risk Assessment is divided into the following sections, providing a detailed discussion of process, approach, and content:

- Introduction
- Disaster Declaration History
- Hazards Identified in Local Plans
- Hazard Profiles
- Risk Assessment Summary

The evaluation of risks or hazards that may affect Puerto Rico potentially is fundamental for the 2021 PRSNHMP since it allows to identify the vulnerability of the territory, its properties, infrastructure, and population. The hazard assessment has the purpose of identifying possible physical, economic, and social impacts, to establish a mitigation strategy directed to reduce or remove the impact and possibility of occurring emergencies or disasters. Also, the evaluation of hazards helps to prioritize the allocation of human, technical, and financial resources required at the state and local levels.

3.1 REQUIREMENTS FOR HAZARD IDENTIFICATION AND RISK ASSESSMENT

The 44 CFR, 201.4(c)(2)(i)[12] provides requirements related to hazard identification and risk assessment for state mitigation plans. The plan must include an evaluation that provides the basis for identifying proposed activities that have as a strategy to reduce losses for the identified hazards. The risk assessments should provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses related to the identified hazards. In turn, the evaluation should include:

- A description of the type, location, and extent of all-natural hazards that may affect the jurisdiction. The plan should include information on previous occurrences of the hazard events and the likelihood of future hazards.
- A description of the jurisdiction's vulnerability to the identified hazards. This description should include a complete summary of each hazard and its impact on the community, including:

    o Vulnerability in terms of the types and numbers of existing buildings and future buildings.
    o Critical infrastructure and facilities located in the identified hazard areas.
    o A summary of the estimate potential loss as presented in the Local Hazard Mitigation Plans(LHMP).
    o General description of land use and pattern development within the community so that mitigation options can be considered in future land-use decisions.

- A summary of all structures insured by the National Flood Insurance Program (NFIP) has been repeatedly damaged by flooding mentioned in the LHMP. Each LHMP include a table showing repetitive property losses and a table of NFIP applications and losses.

3.2 Natural Risks that can affect the state

The evaluation of risks or hazards that could potentially affect Puerto Rico is fundamental to the 2021 PRSNHMP because it allows for identifying the vulnerability of the territory, its properties, infrastructure, and population. The purpose of the risk assessment is to identify the possible physical, economic, and social impacts and establish a mitigation strategy to eliminate or reduce the impact and possibility of an emergency or disaster. Also, hazard assessment prioritizes the allocation of human, technical, and financial resources required at the state and municipal levels.

[12] 44 CFR §201.4(c)(2)(i): "An overview of the type and location of all-natural hazards that can affect the state, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate."

This Plan considered the natural events that predominated in the LHMP. These represent a potential and significant danger according to the present and future damages they may cause to the State. This analysis was based on the geophysical conditions that determine the magnitude and frequency of these events and their geographical distribution, identified in the LHMP.

Although climate change is considered a risk per se, the 2021 PRSHNMP focuses on the dangers that dominated local mitigation plans from a climate change perspective and their impact on altering temperature, precipitation, humidity, wind, water temperature, and increasing extreme weather events. \

The consequences are reflected inthe exposure to floods, catastrophic hurricanes, droughts, among others, raising the need to incorporate mitigation measures to reduce the effects of climate change. The following table provides details of a natural hazard that could affect the State, based on the risks predominated in the local mitigation plans.

Table 3-1: Natural Hazards Affecting the State.

Natural Hazard	Included in the previous Plan?	Included in this Plan?	Comments
Flooding	Yes	Yes	Flooding can be caused by hurricanes, tropical storms, among others.
Landslides	Yes	Yes	The Plan contemplates landslides induced by rain and earthquakes.
Strong Winds	Yes	Yes	Hurricanes and tropical storms can cause strong winds.
Earthquake/Liquefaction	Yes	Yes	This Plan considers both the risk of earthquake and liquefaction as they are correlated concepts.
Drought	Yes	Yes	Since the 2008 PRSNHMP, drought is mentioned as one of the dangers that could affect the Island in the future.
Tsunamis	Yes	No	This hazard is still present but will be addressed in the next update of the PRSNHMP.
Coastal Erosion	Yes	No	This hazard is still present but will be addressed in the next update of the PRSNHMP.
Storm Surge	Yes	No	This hazard is still present but will be addressed in the next update of the PRSNHMP.
Forest Fires	Yes	No	This hazard is still present but will be addressed in the next update of the PRSNHMP.

Source: Local Hazard Mitigation Plans.

3.2.1 Hazard Identification and Risk Assessment

The following subsections provide the required information regarding natural hazards, the areas that may be impacted, the severity/magnitude of the hazards, risks and vulnerability on the population and critical infrastructure. Flood, landslide, extreme wind, earthquake, fault and fissure, and drought hazards are the events presented in this analysis. The selection and prioritization of these risks respond to the findings identified in the local mitigation plans that are currently being updated. An in-depth analysis was conducted in the following subsections: description, theory, history, assessment, and vulnerability. Of these risks, the risk of failure and cracking is presented for the first time as an individual risk in the PRSNHMP.

Floods (Riverine and Coastal)

According to the Federal Office of Emergency Management (FEMA), flood hazard is defined as a general and temporary condition of partial or total inundation of 2 or more acres of naturally dry land area or two (2) or more properties (https://www.fema.gov/flood-insurance/terminology). The National Oceanic and Atmospheric Administration (NOAA) defines flooding as the overflow of water over naturally dry land. This occurs during the occurrence of heavy rains, the presence of storm surges, breaching of structures such as dams and/or levee structures (https://www.nssl.noaa.gov/education/svrwx101/floods/). This report will use the definition of flooding used by FEMA to identify this risk, its spatial distribution on the Island, and its possible implications on life and property.

There are four (4) types of floods in Puerto Rico. These are riverine flooding, coastal flooding, and urban flooding. Also, there is a brief-term for flash floods (2016 PRSHNMP). Riverine flooding occurs when water levels rise above the riverbanks generated by torrential rain that extends for a continuous period.[13] This is associated with the river's overflow; the river can be out of its channel for several hours and up to days (2016 PRSHNMP). Suppose the rainfall event lasts for several hours and the rainfall intensity decreases but remains constant. In that case, it will be challenging for the river or stream to return to its average level. The lack of absorption capacity of flood plains is the primary cause of flood damage (2016 PRSHNMP).

The PRPB identifies that approximately 20,000 properties are in flood zones presented in flood insurance rate maps. According to PRPB, these 30,000 properties may have experienced substantial damage because of Hurricanes Irma and Maria's passage. Flooding is the most frequent and costly natural hazard in the U.S. Floods are usually the result of excessive are generally the result of excess precipitation and can be classified into two (2) categories: flash floods, which are the result of categories: flash floods, the result of heavy rainfall localized in a short period of time over a specific area, and general

[13] NOAA. National Severe Storms Laboratory. https://www.nssl.noaa.gov/education/svrwx101/floods/types.

floods, the result of heavy rainfall localized in a short period of time over a specific area, and general floods, caused by precipitation over a long period of time, caused by precipitation over a long period of time and over a specific river basin. To complement the flood risk analysis, the CDBG-MIT Action Plan contemplates two categories: flash floods and general floods. The risk is also considered as a 100-year flood.

Coastal flooding occurs when low-elevation coastal land is inundated with seawater. Inundation of low elevation coastal land can be caused by storm surge, storm surge, tsunami, sea-level rise, coastal subsidence produced by co-seismic events. Coastal flooding is described in this section as coastal flooding where coastal land is inundated by storm surge action. Storm surges that cause coastal flooding in Puerto Rico are associated with low-pressure atmospheric systems, including tropical waves, tropical depression, tropical storms, and hurricanes, and with the occurrence of extra-tropical cyclonic systems. Extra-tropical systems are low-pressure events located outside the tropics that may have the capacity to generate strong storm surges that impact the north, northwest, and northeast coast of the Island. Other events that can produce swells that cause coastal flooding are the so-called Muertos swells, which are mostly associated with cold fronts. Swell events associated with low pressure and tropical cyclonic systems occur in June through November. Waves associated with cold fronts arise more frequently from November to March, reaching the Mona Passage's coasts to the Anegada Passage.

Urban flooding is when water backups occur in high population areas that result when stormwater inflow exceeds the drainage system's capacity to capture the water (National Academies of Sciences, Engineering, and Medicine, 2019). These can occur from lack of proper maintenance of drainage systems, the trash that prevents water from flowing through existing drains into streets and roadways (2016 PRSHNMP). Moisture can accumulate and cause severe flooding that endangers residential and commercial property. Lack of cleanup by government agencies in creeks, pipes, or canals can cause isolated flooding events in infrequent areas due to the agglomeration of vegetative debris. Another element contributing to this type of flooding is that the land loses its capacity to absorb rainfall because of urban development that impermeabilizes the soil, such as roads, housing developments, and parking lots (2016 ,PRSHNMP).

Flash floods are those where there is a very rapid increase in the flow of a watercourse suddenly, with little or no warning. The cause of this sudden increase in water level may be related to a sudden increase in precipitation, rainfall duration, and dam breaks. This type of flooding can occur throughout all river basins, especially in short rivers with steep topography. Flash flooding is one of the most dangerous floods for human life and is the cause of the highest number of deaths from natural disasters in the world (2016 PRSHNMP). It occurs rapidly and sometimes without opportunity for formal warnings from the National Weather Service. They are the most difficult floods to forecast and the ones that require immediate action by people at risk of being affected.

Severe flooding has been recorded in Puerto Rico in 1899, 1928, 1933, 1960, 1970, 1975, 1985, and more recently due to hurricanes Hugo (1989), Hortense (1996), Georges (1998); Irene (2011), and Maria (2017). These events caused severe damage to private and public property and agriculture, and infrastructure, in addition to causing loss of life. The most recent floods' adverse effects have been more significant due to urban sprawl in coastal and inland valleys, where residences, businesses, and industries are in flood zone.

Landslides

Landslides occur worldwide, in all weather conditions and all types of terrain, causing thousands of deaths and injuries and producing billions of monetary losses each year. Several terms are used interchangeably with the term landslide. These are landslides, mass movements, slope failures (USGS, 2008). A landslide is any downward movement of soil, rock, and organic materials by gravity and influenced by landform (USGS, UPRM, Natural Hazards Center, 2020). The term landslides include a wide variety of ground movements, such as rockfall, slope failure, and debris flow (PR State Natural Hazard Mitigation Plan, 2016). Puerto Rico, due to its geographic and geological nature, is very vulnerable to landslide events. Approximately 80% of the Island of Puerto Rico presents some type of relief. Of this, the mountainous interior is one of the areas of the Island that offers the most significant landslide risk; however, there are also landslide risks in the karst physiographic zone and the coastal regions marked by cliffs and terraces (Hughes, K.S., and Schulz, W.H., 2020).

There are several types of landslides. These are rockfall, rock/earth flow, or a landslide. According to the kind of landslide, the speed of the movement, the probable volume of displacement, the distance at which it will end, and the possible effects of the landslide, the appropriate mitigation measures can be determined (USGS, 2008).This allows authorities and communities to know what possible results will be seen on infrastructure.

The CDBG-MIT Action Plan broadens the scope of landslide risk by incorporating the definition of the term slow landslide as a slow and steady movement of earth or rock downslope, often identified by its log content often identified by their content of tree trunks, twisted pieces of fences, or retaining walls and tree trunks, twisted pieces of fences, or retaining walls, and leaning posts or fences.

It also includes the concept of debris flow defined as a fast-moving mass combining loose soil, rocks, organic matter, air infiltration and water to form a viscous flow that slides downslope as well as debris avalanche as a debris flow that slides rapidly or extremely rapidly. extremely fast.

Figure 3-1 show in detail the types of landslides and their potential effects to infrastructure. (USGS, UPRM, Natural Hazards Center, 2020).

Figure 3-1. Types of Landslides. (Source: USGS, UPRM, Natural Hazards Center, 2020)

Several factors contribute to landslide triggering. These factors can be classified into two main categories: natural and anthropogenic. However, sometimes the susceptibility to these events is exacerbated by a combination of both. In Puerto Rico, the biological factors that mainly contribute to landslide susceptibility are soil saturation and seismic activity. Soil saturation is usually caused by intense and prolonged rainfall, changes in groundwater levels, surface water, and level changes along coasts, lakes, and rivers (USGS, 2008). Of these, heavy rains are one of the factors that have caused the largest landslide events in the past five (5) years on the Island. Due to its latitude and oceanic environment, Puerto Rico is particularly exposed to cyclonic activity (Hughes, K.S., and Schulz, W.H., 2020). Hurricanes and tropical cyclones affect Puerto Rico frequently and are responsible for producing intense and prolonged rainfall with the capacity to trigger landslide events (Hughes, K.S., and Schulz, W.H., 2020). Puerto Rico's vulnerability to landslides from extreme rainfall events is of concern given the projections of increasingly frequent extreme cyclonic systems (GSA, 2019). This is considering the scenario of the occurrence of extreme events associated with climate change.

Landslides can also be caused by seismic activity due to the instability caused by seismic activity in the soil and slope faults (Hughes, K.S., and Schulz, W.H., 2020). The occurrence of earthquakes considerably increases the probability of landslides. On the other hand, the secondary risk of liquefaction caused by soil materials' dilatation could allow rapid infiltration of water (USGS, 2008). Since the Island is in an area of active seismic activity, there is a high probability that these types of landslides will occur due to the occurrence of earthquakes. The event of the southwest seismic sequence occurred between December 2019 and January 2020. An event with Magnitude 6.4 occurred triggered rockslides of steep slopes in the epicentral area's vicinity (Lopez, A.M., Hughes, K.S., Vanacore, E., 2020).

In some cases, human activities can be a contributing factor to landslide events, many of which can be avoided or mitigated (USGS, 2008). Over centuries, various anthropogenic activities in Puerto Rico have contributed to increased susceptibility to landslides, many of which were already naturally vulnerable (Hughes, K.S., and Schulz, W.H., 2020). During the agricultural periods, a dense network of improvised roads developed in the mountainous area. Later, during the urbanization period, dense residential communities' construction spread to the hills and mountainous regions surrounding urban centers (Hughes, K.S., and Schulz, W.H., 2020). Excavation and fill placement associated with road construction throughout the Island's development has led to increased susceptibility to landslides along and near roads (Larsen and Torres-Sánchez, 1993). Besides, informal structures can be found in Puerto Rico, which, due to their Location, can increase physical vulnerability to landslides. It has been observed that this scenario can occur in areas where people have few resources for the construction of their homes and lack knowledge about the exposure and vulnerability of the terrain. The Landslide Guide prepared by the University of Puerto Rico at Mayagüez (UPRM) illustrates the human activities that contribute to landslide susceptibility.[14] **(Figure 3-2)**. In general, landslides result from slope destabilization, disturbance or changes in drainage patterns, vegetation removal, or deforestation.

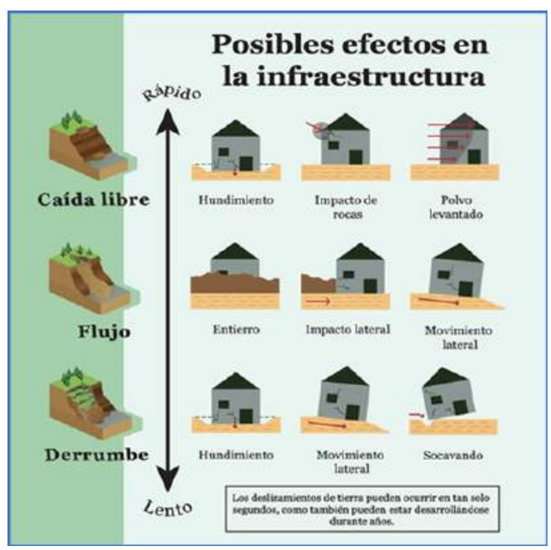


Figure 3-2. Human activities contributing to landslides. Source: USGS, UPRM, Natural Hazards Center, 2020.

Figure 3-3. Possible effects of slip types on infrastructure. Source: USGS, UPRM, Natural Hazards Center, 2020

[14] USGS, UPRM, Natural Hazards Center, 2020

Some of the possible signs of landslide occurrence are leaning trees, water manifestations (water gushing from new places and/or drying up of streams), cracks in the ground, distortion of structures, cracks in streets/walls/doors, leaning infrastructure.

Landslides have adverse effects on the built environment as well as the natural environment. These events affect structures located directly on or near the site of occurrence (USGS, 2008). Structures built on unstable slopes can experience partial damage or destruction when foundations, walls, surrounding land, and surface and subway utilities are destabilized or destroyed. The transportation sector is the most exposed to these events, resulting in the temporary or total closure of crucial routes (USGS, 2008). Following Hurricane Maria landslides were partly responsible for damage to communications and power transmission infrastructure that left much of the Island without power for more than six months (Bessette-Kirton, et al., 2019). Also, debris flows (shallow, fast-moving movements) bring negative consequences for the environment related to high sedimentation of watersheds and reservoirs (Hughes, K.S., and Schulz, W.H., 2020).

Extreme Winds

The concept of extreme winds "has no single definition".[15] According to the ¨National Institute of Water and Atmospheric Research¨ of New Zealand (2016): ¨The physics of extreme winds is a hazard that includes the occurrence of sustained winds and gusts that are strong enough to produce hazardous conditions to the population or cause significant damage to buildings and property. Extreme winds can be caused by tornadoes, cyclonic systems such as hurricanes, descending convective gusts of isolated thunderstorms not associated with an extensive storm system (Turner, 2016), among other meteorological events. In Puerto Rico, extreme winds are mostly related to the occurrence of cyclonic systems such as hurricanes.

From a construction perspective, extreme winds are defined as wind that can exert significant force, or loads, on structures in their path.[16] Hurricane wind loads can cause a great deal of damage. Therefore, most mitigation actions to reduce the risk of damage to structures from hurricane winds involve reinforcing or strengthening the building. According to FEMA,

> *"extreme winds can produce large amounts of debris that can become windborne and puncture the building envelope and openings, posing a threat to human life. Consequently, once a building is punctured, wind-driven rain can enter the building, causing water damage by water entering the building and affecting its contents. In turn, a broken window or glass door can also allow wind pressure to increase inside the house, causing structural damage (FEMA 2010).*

[15] New Zealand National Institute of Water and Atmospheric Research, 2016.

[16] FEMA, Wind Retrofit Guide for Residential Buildings, 2010.

Notwithstanding, wind speed, and Location within the hurricane-prone region, the exposure category is also an important component in identifying a building's vulnerability to wind damage (FEMA 2010). Even as the terrain becomes more open, there is more potential for wind damage. Conversely, areas that are densely populated or have a lot of potential windborne debris may be prone to other types of wind damage"(FEMA 2010). ¨Therefore risk categories have been created that are used to classify structures based on their importance and include considerations such as risk to human life and the social need for the building or construction to function during and after an extreme event¨ (Stone, 2014).

These categories are I, II, III and IV. Category I includes buildings that pose a low risk to human life in the event of a failure, such as agricultural facilities and storage buildings; category II includes houses, apartment buildings, offices, and commerce **(Table 3-2)**. Category III contains infrastructures that pose a substantial hazard to human life, such as schools and assembly buildings with an occupant load above 300. Category IV includes buildings that are designated as essential facilities intended to remain operational under extreme environmental loads, such as power generation stations, police and fire stations, and other structures with critical functions (**Table 3-3**).

Table 3-2: Hazard Category according to the International Building Code (IBC)

Category	Definition
Risk Category I	Buildings represent a low risk to human life in the event of a breakdown, such as agricultural facilities and storage buildings.
Risk Category II	These are those not defined as Risk Category I, III or IV, including houses, apartment buildings, offices and stores.
Risk Category III	Buildings pose a substantial hazard to human life, such as schools and assembly buildings with an occupant load above 300.
Risk category IV	Buildings are designated as essential facilities intended to remain operational under extreme environmental loads, such as power generation stations, police and fire stations, and other critical functions structures.

The NWS has developed the Extreme Wind Warning (EWW) product to warn the public about the occurrence of winds associated with a hurricane's landfall and the need to take shelter indoors in a safe structure during the event. "The Extreme Wind Warning is a text product prepared by the Weather

Forecast Offices (WFOs).i The purpose of this product is to provide short alerts to the public and agencies moments before the rapid onset of destructive winds associated with the inner rain bands of major hurricanes. Warning alerts are strictly for events that pose a significant threat of casualties." (NWS).

Table 3-3: Extreme Wind Warnings issued by the NWS (National Weather Service

Type of Newsletter	Time of Issue
Warning Bulletin	It reports on storms or hurricanes that have developed at sea and do not offer immediate danger to coastal areas.
Surveillance Bulletin	These bulletins are issued when winds may threaten coastal areas within 24 to 48 hours.
Newsletter	They are issued when coastal areas are in imminent danger of being buffeted by winds that will exceed 74 miles per hour within 24 hours.

Extreme winds can be accompanied by secondary hazards such as coastal storm surges that can cause sea intrusion and erosion, heavy rains that can cause flooding and landslides, meteotsunamis in ports and bays associated with the passage of strong tropical waves, and tornadoes with strong gusts that can cause damage or interruptions to electricity, drinking water, communication, and physical infrastructure services.

The Guidelines for Wind Vulnerability Assessments of Existing Critical Facilities[17] describes in detail "ways to assess vulnerability to extreme winds since winds of sufficient velocity can damage critically inadequate facilities. Even this vulnerability is not limited to critically inadequate facilities because there are well-designed facilities, i.e., well-constructed and maintained, that can be damaged in a wind event that exceeds the facility's design criteria. In Puerto Rico, after Hurricane Maria's passage, it was observed how most of the structures have minimal resistance to strong winds due to different factors such as inadequate design, deterioration of materials, poor installation, construction permits, lack of income, and limited responses from the government.

This guide mentions that normal operations of a critical facility may be disrupted by wind damage, including:

• Water leakage caused by wind damage.
• Water infiltration due to wind-driven rainfall.
• Evacuation of building occupants may be required

[17] Federal Emergency Management Agency. Guidelines for Wind Vulnerability Assessments of Existing Critical Facilities. 2019.

As part of mitigating against this risk, it is imperative to conduct "comprehensive wind vulnerability assessments" (FEMA, 2019) to account for the most significant wind vulnerabilities. Building owners can use these "thorough assessments, design professionals, mitigation grantmakers, and state, local, tribal, and territorial government agencies that develop mitigation plans" (FEMA, 2019) and even community organizations to help them become self-managed, aware of this risk, its implications, and how they can address it.

On the other hand, the guide highlights the most common vulnerabilities, according to numerous research studies, which point to damage caused by high winds:

- The roof structure detaches or collapses.
- The collapse of the fire station apparatus doors.
- Glass breakage from windborne debris generated by hurricanes or tornadoes.
- Roof coverings.
- Rooftop equipment.

It is noted that the damages mentioned in the above list have been widespread in Puerto Rico due to extreme winds. Therefore, it is necessary to carry out evaluations of houses' performance to consider how prepared and ready we are to face any other atmospheric event involving extreme winds.
According to the fifth amendment to the Disaster Recovery Action Plan for the use of CDBG-DR funds in response to Hurricanes Irma and Maria (2017):

> *"The level of damage caused by the hurricanes was exacerbated by the widespread destruction of inadequate housing structures and damage to abandoned and unmaintained residences. It is estimated that between 45% and 57% of Puerto Rican households have built or maintained homes using informal construction methods, i.e., self-driven construction methods that are completed without the intervention of an architect or engineer, without the proper permits, and often in non-compliance with land use codes. In many cases, informal construction is done without the appropriate title to the property. This type of construction reduces the structural integrity of homes and their ability to withstand natural environmental conditions, so they cannot withstand hurricane conditions [such as extreme winds] ... A market reality is that financially overburdened households face exacerbated challenges related to finding safe, affordable housing. There are more than 14,500 rental households and more than 13,300 owned homes overcrowded by a factor of one person or more [...].*
>
> *In terms of critical infrastructure, Puerto Rico's electrical system already deteriorated. Maria caused the total loss of electric service in all seventy-eight (78) municipalities. The hurricane passage caused severe damage to a large part of the 2,400 miles of transmission lines, the 30,000 miles of distribution lines, and the 342 substations on the Island."*

Suppose one wishes to mitigate in a safe, dignified, and conscientious manner. In that case, one must ensure that the level of risk performance - including poor communities - is acceptable to avoid other disasters on the Island. Therefore, all homes with blue awnings (from Hurricane Maria's impact in 2017) should be addressed as quickly as possible. In this way, these mitigation recommendations have some concrete and responsible function.

Earthquake (Liquefaction and Acceleration)

An earthquake "is the sudden and rapid movement caused by the release of energy arising from within the Earth. This movement occurs along the surface between two blocks, which is known as a fault. " (Puerto Rico Seismic Network, 2020). According to the USGS, "[...] earthquakes can be caused by the constant movement of tectonic plates, which tend to jam at their edges due to friction. When the tension between two plates exceeds the friction, an earthquake occurs releasing the accumulated energy. "The World Health Organization (2020)-an entity of high rigor and importance before any natural risk event-, describes an earthquake as "[...] a tremor of the earth caused by waves that propagate through the earth's crust and below it, causing cracks in the surface, shaking, vibrations, liquefaction, landslides, aftershocks or tsunamis.". Also, they are caused by sudden slippage on a fault due to the release of energy accumulated inside the Earth and along the surface between two blocks or fractures of the Earth's crust, which is known as a geologic fault (Seismic Network, 2020).

In turn, the Seismic Network states that the movement of tectonic plates directly or indirectly causes earthquakes. The plate tectonic theory presents that the lithosphere is divided into a series of plates or blocks in continuous motion at different speeds and directions. When these plates or blocks slide close to each other and interact with each other, they accumulate energy and stress that, when released, can cause an earthquake. The earthquake redistributes along the fault, causing the energy to shift and reduce the plates' accumulated tensions. These rigid plates "float" in the Earth's mantle; convective motion in the cover "pushes" the plates around the Earth." The margins defined by the interaction of these blocks are convergent margin (collision between plates), divergent margin (separation of plates), and transform margin (friction between plates) (**Figure 3-4**) The most intense earthquakes are mostly associated with convergent and change plate margins.

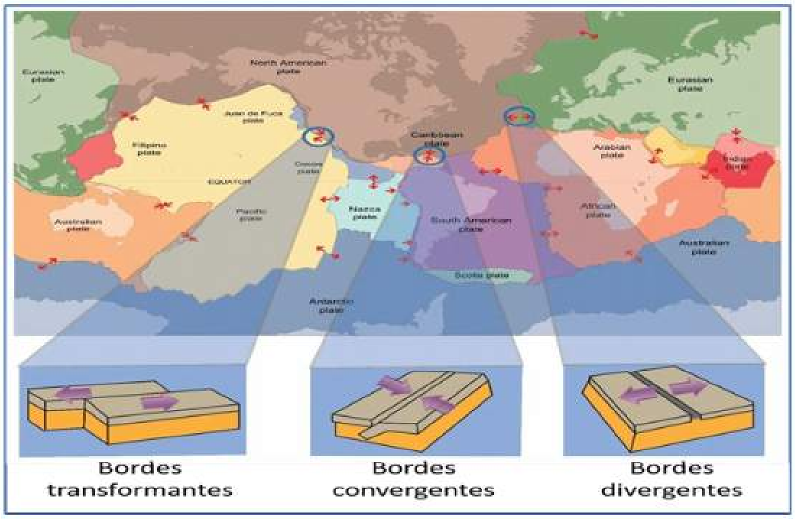


Figure 3-4 Types of tectonic plate boundaries (margins).

The energy released in an earthquake is through seismic waves. Seismic waves travel from the hypocenter to the surface once they expand inside the Earth and travel through different ground materials (EcoExploratory, 2020). Waves are divided into two main categories, Body Waves and Surface Waves. Body waves travel through the interior of the Earth, which is subdivided into P-waves and S-waves. In this case, P-waves are the first to be recorded on seismic instruments as they are the fastest traveling in the interior of the Earth; they have a vertical motion (up and down) and move through solid rock and fluids. However, S-waves travel at a slower speed. Therefore, they are the second fastest to be felt in an earthquake. The motion of these waves is horizontal (sideways), and, unlike P-waves, they travel only through solid material. On the other hand, Surface Waves are waves that travel through the Earth's crust and arrive after the body waves. However, these waves are associated with the destruction and damage caused by earthquakes, since the shallower the event, the more significant the impact of surface waves, and are subdivided into R waves (Rayleigh waves) and L waves (Love waves).

R-waves are characterized by a rolling effect under the ground causing an upward and downward movement of the ground and side to side, causing most of the vibrations on the surface during the event. Therefore, it is known as the most potent and most impactful wave. Finally, L-waves are characterized by horizontal or lateral movements, which are dangerous for building foundations as they weaken them. The position of this event can be described through the Location of its hypocenter and epicenter.The hypocenter (focus) is the "point on the fault where the first movement or rupture occurs during an earthquake," and the epicenter is the point of the projected focus on the surface (Puerto Rico Seismic Network) (Figure x). It is at the hypocenter located within the Earth's crust, where the rock's rupture begins to occur.

The hypocenter is determined by its latitude, longitude, and depth of the event. Earthquakes are referred to as shallow (0 45 miles), intermediate (45- 185 miles), and deep (185 miles). In the epicenter case, "the latitude and longitude of the event are reported" (Puerto Rico Seismic Network).

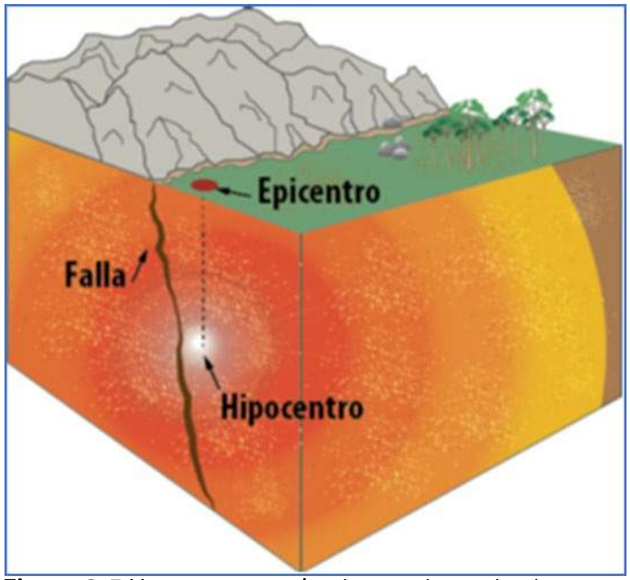


Figure 3-5 Hypocenter and epicenter in a seismic event.
(PR Seismic Network)

To fully understand the risk of earthquakes and their profile, there are three terms to characterize the size of the earthquake: intensity, magnitude, and acceleration. Earthquake intensity is measured according to the degree of shaking felt in different places where the event was felt. (PR Seismic Network). This can be determined in a particular area according to the damage it leaves in its wake on the place's infrastructure, people, and soil. The scale used to measure the intensity of the event is the Modified Mercalli Intensity Scale. This scale includes intensities from I (the event was not felt) to XII (event left destruction (PR Seismic Network, 2020).

The magnitude of an earthquake is determined given the amount of energy that was released in the event.Among this scale is identified the Richter and Moment Magnitude scale. The Richter Magnitude Scale is used to measure how much energy was released and how strong it was. However, this scale is no longer used to measure the magnitude of the event. Moment Magnitude relates directly to the fault's properties, how far it slipped and how much the material resisted displacement (PR Seismic Network, n.d.). It is stated that this scale "does not saturate for large magnitudes (>6.5) mb and Ms it can underestimate the size of the event" and additional "retains the simplicity of the other magnitude scales (order of 1 is comparable to the other magnitudes" (PR Seismic Network).

Earthquakes also describe in terms of ground acceleration. During the event, the Earth is shaking, but it is also accelerating. This can occur because the seismic waves arrive at different speeds. This last tool of measuring an event is considered by engineers when designing earthquake-resistant buildings and structures.

Aftershocks also characterize earthquakes after the main event. These are smaller-scale earthquakes that occur after the main event and are concentrated in the same area. Aftershocks can continue to occur for periods of days, weeks, months, and even years. However, another scenario to be discussed is the formation of swarms which are characterized as a series of seismic events that occur in the same area with similar characteristics, such as magnitude and intensity, for a given time. An example of swarm formation can be seen in the seismic events that occurred in late 2019 and early 2020 in southern Puerto Rico, where about 500 seismic events greater than M 2.0 were recorded, including the M5.8 and M6.4 tremor (Puerto Rico Statistics Institute, 2020) (**Figure 3-6**) .

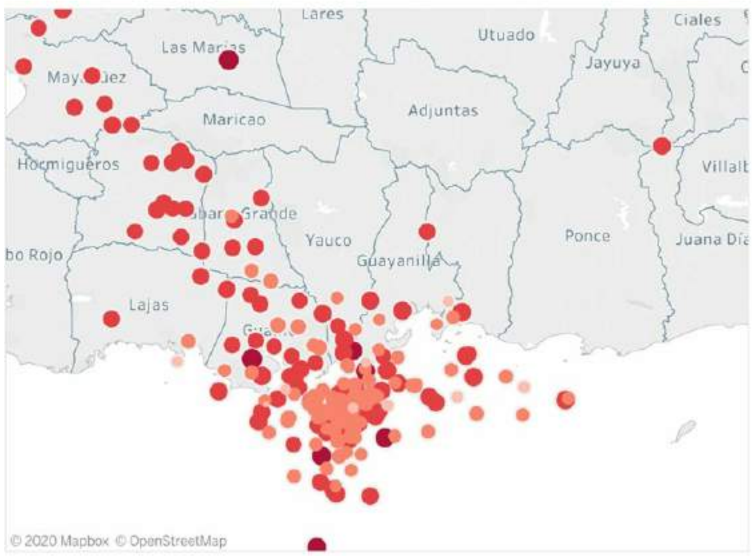


Figure 3-6. Seismic swarm that occurred in the Southern area of Puerto Rico. (Puerto Rico Statistics Institute, 2020).

Tectonic scenario of Puerto Rico

Puerto Rico has a high probability of being affected by an earthquake due to its Location within the Puerto Rico-Virgin Islands microplate. This microplate is situated between the North American tectonic plate and the northeastern section of the Caribbean plate. According to the USGS, this plate is an active plate that can produce high-intensity earthquakes.

The tectonic margins or edges included in this plate are of subduction and transform convergence nature. The zones with the highest probability of seismic activity in Puerto Rico are in the north. The Puerto Rico Trench is located, to the South where the Muertos Trench is located, to the east with the Anegada Trench, and to the west in the Mona Canyon zone. All these zones can produce seismic events of M7.0 (magnitude) or greater, according to studies and historical data collected (Clinton, J.F., 2006).

Also, surface ruptures have been studied in the internal fault South of Lajas and other areas of the Southwestern part of the country, extending to Ponce, which can generate events of up to M7.0. In recent years, other faults have been discovered, such as the Punta Montalva fault, located in the southwest of the Island, which has focused on the most recent seismic events of the southwest seismic sequence. The identification of this fault was based on a detailed analysis of geophysical data, satellite images, and field mapping. Constant seismic activity has been identified, causing numerous tremors with magnitudes greater than M5.0 (Roig-Silva et al, 2013).

The Puerto Rico Seismic Network affirms that the Island is in one of the most active seismic zones globally due to its geographic Location, which is why tectonic movements are frequently registered. Besides, according to USGS data, the Island is in one of the regions where earthquakes are generated more often. "During several days in 2011 (April 4, 22, 23 and 26 May), Puerto Rico was the place in the world where the most earthquakes were recorded, according to the USGS." (BBC, 2020). By 2020, the Puerto Rico region is identified as one of the world's most active tectonic zones.

The recorded history of earthquakes in Puerto Rico dates to 1615 when on September 8 of that year, an earthquake occurred in the Dominican Republic, causing damage in Puerto Rico. After several other incidents, on August 30, 1740, an earthquake of intensity seven (7) occurred, which caused direct damage to the Island with the destruction of the Guadalupe Church in the Municipality of Ponce. Thus, "[i]n Puerto Rico, from 1670 to the present day, four (4) significant and destructive earthquakes have occurred in the following years; 1670, 1787, 1867, and 1918, respectively. This historical record of earthquakes reflects a cycle of 51 to 117 years or an average of 83 years for the recurrence of destructive earthquakes." (PR Seismic Network). From this date to the present, with the earthquake reported on January 7, 2020, in Guánica, the archipelago of Puerto Rico has been exposed to and suffering damage from earthquakes. It is essential to keep in mind that the Puerto Rico microplate, the Puerto Rico Trench, and the Virgin Islands plate are intrinsic to the national risk profile.

Failures and Earth Fissures

In Geology, a fault is a fracture or fracture zone along which a relative displacement of rock blocks has occurred, parallel to the fracture or at the fracture surface (Bates & Jackson, 1980). This relative displacement of geological faults can range from centimeters to kilometers, as is the case of the well-known San Andreas Fault, located in California (Tarbuck & Lutgens, 2005). Different types of faults will be produced depending on the direction of displacement or movement of the rock blocks. Among the types of faults are vertical displacement, normal faults, reverse faults, horizontal displacement, and transform faults (Carpio, 2017).

Vertical displacement faults are those in which the movement is relative but occurs parallel to the dip or slope of the fault, so that one rises above the other or vice versa (RSN, 2019). This displacement is divided into two types of faults. Normal faults are generated by horizontal tension, causing one block of rock with a 60-degree dip to move down vertically compared to the other rock block (Tarbuck & Lutgens, 2005). Reverse faults are those generated by horizontal compression, obstructing rock less than forty-five (45) degrees to move up vertically compared to the other rock block (Tarbuck & Lutgens, 2005). Horizontal displacement faults are those in which movement between faults occurs parallel, lateral, and planar to the fault surface. An example of this displacement is the transform faults, which are those in which the movement along the fault crevasse is horizontal, causing the block of rock on one side of the fault to move in one direction. In contrast, the block of rock on the other side of the fault moves in the opposite direction (Tarbuck & Lutgens, 2005). It should be noted, however, that faults are usually more complex than these descriptions suggest. Often the movement along a fault does not occur in one way, and thus, oblique displacement faults can arise, which are those with vertical, horizontal, or combined plate movements (Tarbuck & Lutgens, 2005).

A fissure is a fracture that can be formed by tectonic processes and hydrologic processes associated with groundwater deposits (Zhao Long et al., 2020). These fissures are "fractures that open significantly by cleavage with direction normal to the fracture plane" (Mitcham, 1964). They may or may not be connected to a major fault, but certainly, when associated with tectonic processes, they are the consequence of energy release during a telluric event (Roig-Silva, 2010).

In Puerto Rico, several studies have been conducted where faults and fissures have been characterized. Many of these studies have been driven by the USGS on the seafloor. Recently, geologist Uri Brink and his USGS team identified numerous faults on the island shelf south of Puerto Rico. These faults may represent ruptures associated with the January 7, 2020 Magnitude 6.4 earthquake (Celestial, 2020). Even with the presentation of the recent studies conducted by the USGS and the UPRM Geology Department (Adames-Corraliza, 2017), additional studies will need to be undertaken promptly to identify and/or characterize the Location and current conditions of these faults and fissures located on the Island. Indeed, this information is basic and necessary to define the present risk scenario in detail due to the presence of faults and fissures in Puerto Rico.

In Puerto Rico, the distribution of faults and fissures is associated with the definition of the tectonic setting of the Island. **Figure 3-7** presents the main geologic structures that divide what is understood as microplates or independent tectonic terrains (thick white lines). The red circles represent the different earthquakes' epicenters regardless of their depth and in size proportional to their magnitude. Most of the earthquakes recorded in the central zone of the channel are more profound than 75 km and, on the contrary, those that approach the NorthAmerican plate and the Trinchera de Los Muertos are generally less than 35 km deep, showing a clear pattern of double polarity in the subduction of the North American plate below the Hispaniola microplate to the north and, to the South, by the subduction of the Caribbean plate below the Hispaniola microplate.

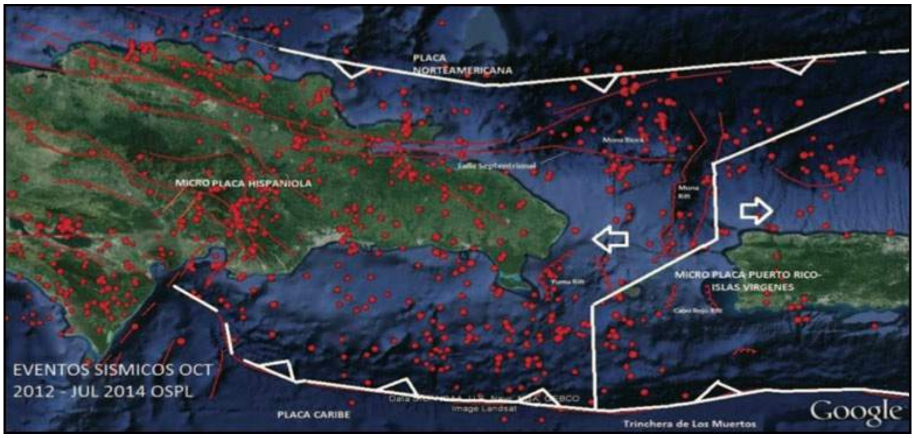


Figure 3-7.

Approximately five-hundred and four (504) faults have been identified in Puerto Rico (Vázquez, 2019). The most recognized faults in studies around the Island are Mona Canyon, Northern Fault Zone, Puerto Rico Trench, Sombrero Seismic Zone, Mona Passage, and the 19° N. Some of these faults are located on land and others, on the seafloor (Celestial, 2020). Therefore, Puerto Rico is considered a region of high seismic risk (Vázquez, 2019). The knowledge of the state of the faults is essential to evaluate and/or model the possibilities of the occurrence of tsunami risks, as well as to define possible scenarios of what magnitude of earthquakes could be generated from the characteristic of the fault.[18]

The earthquakes' possible magnitudes that could occur associated with the identified faults were identified (Huérfano, 2003). However, the report indicates that Puerto Rico could experience earthquakes of magnitudes of 6.6 to 7.7 based on the characteristic of the fault identified in and near its Location (Huérfano, 2003). **Table 3-4** presents information based on nine (9) recognized faults in Puerto Rico with their relative Location, absolute Location, and potential magnitude if they were to trigger an earthquake. **Figure 3-7** presents a map showing the absolute Location of the most known faults using Puerto Rico as a reference (each fault is differentiated with a different color, and the distribution of these faults can be seen).

[18] Huerfano, V. Mode Faulting in the Local Zone of Puerto Rico (LZPR). 2003. It presented the methodological theory used to determine the activity of the eight best known or best studied faults in Puerto Rico.

Following the December 2019 and January 2020 earthquake event, the USGS conducted a detailed study of future aftershock approximations following the event. Using the epidemic-type aftershock sequence model (or ETAS) methodology and the seismic reports of the January 7, 2020's event, they estimated the approximate duration of aftershocks in the area surrounding the events (Van der Elst et. al., 2020). Thus, this report argues that the probability of occurrence of a magnitude five (5) and higher magnitude six (6) earthquake event in southern PR will not fall below 25% during the next year (2020), as well as during the next decade (Van der Elst et. al., 2020). However, it is emphasized that these findings are conditioned to the process of aftershocks that will continue to occur in the South of the Island, exclusively, which is not related to other telluric events on the Island.

Table 3-4. Identification by the name of Puerto Rico's faults.

Fault name	Location Relative	Absolute location (x,y)* (x,y)*	Potential Magnitude	Comments
Anegada Fault	South-Southeast	(17.91°N, -64.39°W) to (17.72°N, -66.49°W)	7.7	(Styron et al., 2019)
Mona Fault (East)	Northwest	(19.10°N, -67.32°W) to (18.52°N, -67.26°W)	7.5	(Styron et al., 2019)
Mona Fault(West)	Northwest	(18.98°N, -67.50°W) at (18.42°N,-67.-64°W)	7.5	(Styron et al., 2019)
Great Northern Fault Zone	Center-East	(18.18°N, -65.72°W) to (18.31°N, -66.30°W)	6.8	(Styron et al., 2019)
Great Southern Fault Zone	Midwest	(18.05°N, -66.51°W) to (18.28°N, -67.09°W)	6.6	(Styron et al., 2019)
Failure of the Dead	South	(17.45°N, -64.16°W) to (17.23°N, -68.30°W)	7.6	(Styron et al., 2019)
Puerto Rico Trench	North	(19.72°N, -63.23°W) to (19.59°N, -68.38°W)		(Styron et al., 2019)
Northern Fault	Northwest	(18.99°N, -67.48°W) al (19.10°N, -68.35°W)	7.8	(Styron et al., 2019)
Hat Failure	Southeast-southwest	(18.86°N, -63.69°W) to (17.94°N, -65.42°W)	7.7	(Styron et al., 2019)

Figure 3-7. Distribution of Major Faults in Puerto Rico (Source: Valeria Bonano, UPR-GSP; geospatial databank source: Styron et al., 2019).

For two decades, the Puerto Rico Seismic Network attached to the University of Puerto Rico Mayagüez Campus (UPRM) studied the seismological panorama of the North Boquerón-Punta Montalva fault in southern PR. The relative Location of the previous fracture, together with its absolute Location, is shown in **Table 3-5.**

Since 2006, seismologists and geologists have documented seismic activity in the Southwestern region. Roig- Silva (2010) mentions that "observations and analysis made by Clinton et al. (2006), demonstrates that although southwestern Puerto Rico is the most seismically active area on the Island, the seismic activity cannot be directly related to previously mapped faults. Most of the seismicity in southwestern Puerto Rico occurs at shallow depths."

Table 3-5. Identification of the North Boquerón-Punta Montalva Fault

Fault name	Location Relative	Absolute location (x,y)* (x,y)*
North Boqueron-Punta Montalva Fault	Southwest	(18.00°N, -67.21°W) to (17.97°N, -66.91°W)

Because of this, seismologists study the surface reflections of these movements in the area, resulting in the finding of three connective faults that extend from the north of Boquerón Bay, through the Lajas Valley to connect with the Punta Montalva region and culminating with it, in the Ensenada las Pardas in Guánica.

This North Boquerón-Punta Montalva fault exhibits compression of the northeast microplate in the southwest microplate's direction, evidencing a left-lateral fault movement towards the west of PR **(Figure 3-8).**

To evidence the identification of the North Boquerón-Punta Montalva fault, an alluvial stream displaced due to the fault was in the area; it could be identified through satellite image studies. On the other hand, the fissures placed in proximity to the fault are interpreted by experts as topographic expressions of the fault. They are located based on reported or recognized telluric events in the area. Due to the geological and seismological composition of the fault, experts suggest that the fault is in the process of subsidence. However, evidence suggests that this fault system is a relatively young one and that it was recently activated due to the reactivation of older faults (Roig-Silva, 2010). Finally, the alluvial sediment located in the vicinity of the fault shows that surface deformity, because of pressure from older faults, has not occurred. That, however, the pressure has been reflected by the creation of additional fissures in the vicinity of the fault.

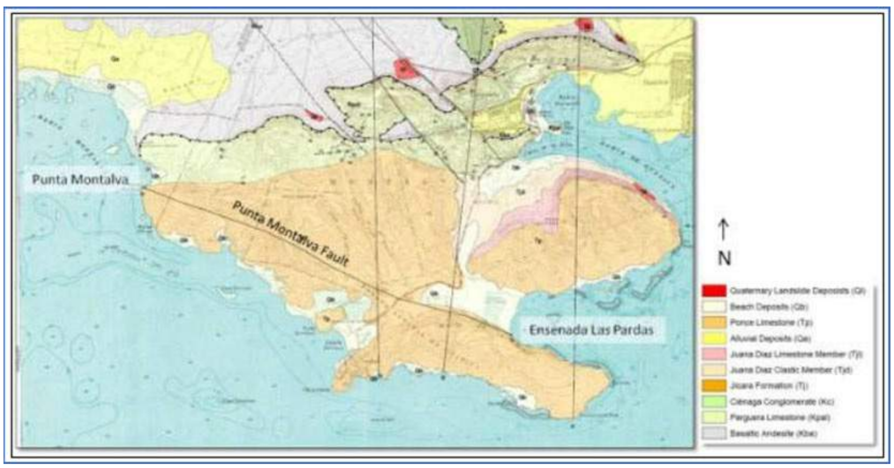


Figure 3-8. Location of the North Boquerón-Punta Montalva fault (Roig-Silva,

After the January 7, 2020 earthquake event, studies conducted by the USGS reveal the existence of new faults in the southern area. In this case, the scientist Uri Brink confirmed a submarine extension of the North Boquerón- Punta Montalva Fault. It is stated: "Several more faults had been tentatively identified lying 7 and 15 km (4 and 9 miles) offshore, in waters up to about 1,000 m (3,300 feet) deep, also within areas identified as the epicenters of some of the latest earthquakes (Celestial, 2020)". There is certainly a need for further studies in the area to determine the status of seismic activity, possible magnitude, type of slip, last movement, absolute Location, among other data, of these newly discovered faults.

Drought

Drought can be understood as a temporary anomaly of precipitation or natural flow, where the shortage of rainfall is prolonged in such a way that it causes a severe hydrological imbalance (OE-2020-049). This may or may not result in interruption of standard drinking water service, loss of crops, and impacts on flora and fauna, among others. The severity of the drought will depend on moisture deficiency, duration, and the territorial extension of the affected area (Colón, 2009). The situation can worsen when there is a deficiency in precipitation for a prolonged period and constant demand for water, resulting in a water shortage for some activity, industrial, community, or environmental sectors (FEMA 2014). When water availability is insufficient to meet expected or steady demand, this period may be prolonged and become an abnormally dry or prolonged period of deficient precipitation concerning the statistical average of several years for a region. These periods can be understood as seasons, one year or several years. In essence, drought is determined by the balance between water supply and demand. The effect of drought is governed by the interaction between a natural event (less precipitation or water inflows than expected) and the need for water supply, with human activities normally exacerbating the impact of a drought. In terms of operational definition, it is essential to note that these are divided into four, which start from six (6) general classes of droughts (Eslamian & Eslamian, 2017).

Six (6) classes of drought are identified. These are drought: 1) meteorological, 2) climatic, 3) atmospheric, 4) agricultural, 5) hydrological, and 6) water management **(Table 3-6)**. From these (6) classes, four (4) operational definitions are developed for drought measurement. These are drought: 1) Meteorological, 2) Agricultural, 3) Hydrological, and 4) socioeconomic and environmental **(Table 3-7).** These categories vary based on their implications in the environmental, social, and economic contexts.

Table 3-6: Types of Drought

Meteorological Drought	Defined in terms of precipitation deficiency in absolute amounts for a given period.
Climate Drought	Defined in terms of precipitation deficiency, in percentages of average values.
Atmospheric Drought	Defined not only in terms of precipitation but also in terms of possible temperature, humidity, or wind speed..
Agricultural Drought	Defined primarily in terms of soil moisture and vegetation behavior. This includes green drought, defined as a period of limited rainfall resulting in insubstantial vegetation growth.

Hydrological Drought	Defined in terms of reduced flow, reduced storage in lakes or reservoirs, and reduced groundwater levels.
Drought in Water Management	Defined in terms of water supply shortages caused by the failure of water management practices or facilities, such as an integrated system of surface or subway water supply and storage, bridging normal or abnormal dry periods, and balancing water supply throughout the year. * In Puerto Rico, drought in water management is associated with socioeconomic and environmental drought.

Source: Eslamian, S. and Eslamian, F. 2017

Table 3-7: ***Operational Definitions of Drought.***

Meteorological Drought	Period of abnormally dry weather, long enough for the lack of water to cause a severe hydrological imbalance in the affected area.
Agricultural Drought	A climatic excursion involving a shortage of precipitation sufficient to affect agricultural production adversely.
Hydrological Drought	Period of below-average water content in streams, lakes, rivers, aquifers, and soils.
Socioeconomic and Environmental Drought	A period in which a decrease in water supply relative to demand affects human activities and ecosystem function to the point of failure. This may be associated with elements of meteorological, hydrological, and agricultural drought.

Source: Eslamian, S. and Eslamian, F. 2017

Drought events in Puerto Rico are monitored by the USDM, DNER, USGS and the Puerto Rico Climate Change Council (PRCC). For this Plan's purposes, the types of drought to be evaluated will be socioeconomic, environmental, and meteorological drought.

3.3 Chronology of Hazard Events or Emergency Declarations (2017-2020)

For the period analyzed, nine natural hazard events were recorded. FEMA classified two of them as Disaster Declarations, three as Emergency Declarations, and four as combined declarations. The following table provides details of the events at the island level, which could either directly or indirectly affect the State Government.

Table 3-8: Chronology of Hazard Events.[19]

Date of the Occurrence	Type of Hazard	Description of the Event	DR/EM No. (If applicable)
Sept. 13, 2020	Storm and Flooding	Severe storm and flooding affecting the Municipality of Arecibo.	DR-4571-PR
Aug. 21, 2020	Tropical storm	Islanwide impact with heavy rains and strong winds causing severe flooding particularly in the center and west of the Island. The system brought winds over 39 miles per hour with gusts up to 70 miles per hour (112 kms./hour).	EM-3537-PR
Jul. 29, 2020	Hurricane	The system produced a lot of water and flooding, as well as strong winds throughout the Island.The event produced risks associated with strongwinds of 50 mph. It also brought heavy rains that intensified flooding problems in several municipalities of Puerto Rico.Puerto Rico. Between 3 to 6 inches of rain and in some isolated areas 8 inches of rain were received, while storm surge was estimated to reach 10 to 18 feet, producing coastal flooding or storm surge. The event's rain turned several streets into fast-flowing rivers and toppled trees and some telephone and electrical cables. The National Guard rescued at least 35 people, including two newborns.	DR-4560-PR
Jul. 27, 2020	Tropical Cyclone	The Potential Tropical Cyclone Nine was a system that produced a lot of water and flooding, as well as strong winds in the Puerto Rico area. It impacted the Island with heavy rain and strong winds causing severe flooding in the center and west of the Island.	EM-3532-PR

19 https://www.fema.gov/disasters/disaster- declarations?field_dv2_state_territory_tribal_value=PR&field_year_value=2018&field_dv2_declaration_type_value=All&f ield_dv2_incident_type_target_id_selective=All

		• 01.06.2020: Earthquake of intensity M 5.8 and its aftershocks At 8:50 a.m. a second earthquake of M 4.6 was confirmed. Its location gave to 12.38 km of this-south-east of Guánica. At 5:37 p.m., another earthquake of M 4.27 was registered, located in Mayagüez 20.29 km southeast of Guánica. • 01.07.2020: According to the USGS, an earthquake of intensity M 6.5 was registered at 4:24 a.m., affecting all 78 municipalities, mainly the southern area. The epicenter originated approximately 8.4 miles southwest of Ponce, with a depth of 8 miles. Emergency response efforts were implemented retroactively to December 28, 2019 and subsequent dates.	
Sept. 5, 2019	Tropical Storm Dorian	The effects in Puerto Rico were relatively limited due to its northeastern movement. Wind gusts in the island-municipality of Culebra reached 62 mph (100 km/h) and 35 mph (56 km/h) in San Juan. Approximately 23,000 homes lost electricity throughout the territory.	EM-3417-PR
Sept. 20, 2017	Hurricane	Hurricane Maria, a Category IV tropical cyclone, impacted the Island causing widespread catastrophic damage.	DR-4339-PR EM-3391-PR

Source: FEMA Declared Disasters**.**

3.4. Methodology Used to Determine The Probability of Future Events

As required by applicable regulations, the following methodology was used to determine the likelihood of future natural hazard events that may affect the state government:

• Hazards occurring less than once every five years - Low Probability.

• Hazards occurring at least once every five years - Moderate Probability.

• Hazards occurring at least once a year - High Probability

In addition, the 2021 PRSHNMP recognizes the methodology used by the CDBG-MIT Action Plan addresses the likelihood of future events for each of the risks. The Hazard Frequency Analysis Results (HFAR) consists of a comprehensive hazard assessment containing four (4) basic components: hazard identification; hazard event profiling; asset inventory; and an estimate of potential human and economic losses based on exposure and vulnerability of people, buildings, and infrastructure. According to this definition, risk is the potential for an adverse outcome assessed in terms of the threats, vulnerabilities and consequences associated with an incident, event, or occurrence.

The assessment of potential hazards is a critical task in developing the mitigation strategy and establishing an ongoing effort in future evaluations and updates of the PRSNHMP. The methodology used for data collection and description of the hazards that could potentially affect Puerto Rico, among other aspects, is presented below. Also, the HFAR This analysis was integrated to the six (6) risks of this Plan.

3.5. Methodology Used for Data Collection

The 2021 PRSNHMP data collection and update process is based on an incremental basis, incorporating data and information produced in recent years on the identification, incidence, and other aspects of natural hazards. The data used for the 2016 PRSNHMP were not available for this update, representing a limitation of this methodology.

Given this scenario, as a first step, an extensive effort was made to obtain complete information to update the information available during the period of validity of 2016 PRSHNMP (databases, maps, technical data, and studies and analysis carried out in response to disasters and emergencies that have occurred). The sources of information included state government agencies, federal agencies, and private entities. In addition, the information contained in the approved LHMP was incorporated with the purpose of combining them and making them a fundamental part of priority setting and the fomulation of mitigation strategies. A key source of information was the Island Wide Risk Assessment, used to elaborate the local mitigation plans. The data was updated with databases from additional technical studies and information provided by various government agencies, federal agencies, and specialized organizations.

The review of the local government plans focused on identifying the following areas:

- Natural hazards that may affect municipalities.
- An estimate of potential losses associated with the identified risks.
- Mitigation goals or objectives set.
- Mitigation activities or projects proposed by local jurisdictions to address identified natural hazards.

The process of collecting data and information from the various government and private sectors consisted of solicitation through letters to agency heads, presentations to representatives of concerned agencies and entities, meetings with government officials and technical staff, and identification of technical studies conducted through FEMA and the PREMA-COR3. **Appendix 2-4** includes copies of letters sent to agencies requesting information for this purpose. The information requested from government agencies consisted of:

- Inventory of critical agency facilities with information related to each facility, such as location with coordinates, identified vulnerability to natural hazards, the replacement cost of the facility, and estimated replacement cost of the facility contents.
- Inventory of mitigation projects conducted in recent years and planned, including data such as type of project, physical location, date completed or expected to be completed, approximate cost, and the population that would benefit from the project.

The second step consisted of analyzing all the information presented in the 2016 PRSNHMP to corroborate its accuracy and validity and determine the need to update it. The third step was to update the geographic databases generated for the local mitigation plans with data provided by organizations, state agencies, and federal agencies.

Geographic data on natural hazards provided by organizations and agencies include:

Table 3-9: 2021 PRSHNMP Geographic Database Sources

Use	Data	Source
Database	Census Population	Hazus, 2010 US Census Bureau
Database	Critical Infrastructure	PRPB; ABFE
Floodings	Depth Grids	FEMA
Landslides	Landslide Susceptibility Index	US Geological Survey
Strong Winds	Eolic Zone Maps	American Society of Civil Engineers
Earthquake	Liquefaction Index	US Geological Survey; Red Sismica
Drought	Historic Occurrences	US Drought Monitor

Geographic data related to population and housing were obtained from the US Census Bureau and American Community Survey reports. Various state government agencies provided critical infrastructure data, such as Puerto Rico Public Building s Authority, Puerto Rico Fire Bureau.

Table 3-10: State Government Critical Infrastructure.

Geographic Information	Source of Information
Pluvial and Sanitary Sewage, Hydrants, Treatment Plants, Water Service Lines and Reserve Tanks, among others	PRASA
Landfills	PRPB
Transmission Lines, Substations and Thermoelectrics, Dams, among others	PREPA
Fire Stations	PR Fire Bureau
Roads, bridges, toll plazas, stations, and urban train alignment, among others	Department of Transportation and Public Works
Educational Centers and Schools	PR Department of Education; Public Buildings Authority
Communication Towers	PR Telecommunications Bureau
Airports, Ports, and Heliports	PR Ports Authority

Once the technical and geographical bases were updated, an analysis began to determine the impact of the possible risks. Below is described the study of the geographical data completed by the University of Puerto Rico Graduate School of Planning.

The use of the data set collected allowed for identifying the population and homes in each of the risk areas and the possible impact on critical infrastructure. To assess the overall risk's intensity, all geographic levels of risk were grouped into a new level through the GIS. In this way, the elements of risk on the population and housing units were spatially analyzed.

The methodology related to data collection and vulnerability assessment of each risk population and infrastructure are included in the subsections corresponding to each of the risks covered by this Plan.

For the risk analysis on critical infrastructure, the same exercise described above was done, but in this case, the spatial identity function is used in those geodatabases at that point. This way, the risk level is transferred to the data point (location of critical infrastructure). Once the data of each of the risk levels was obtained (individually), proceeds to create the aggregate risk level to get all the risks in one geodatabase. The final tables with the aggregated risk data serve as a tool to determine an approximate of the population and housing at risk, and the amount of infrastructure and the risk level in which it lies. For population and housing, the municipality is organized so that a rank may be created to determine priorities of acting and mitigation. These databases are in the geodatabase format of ArcGIS since it is the format that is managed mainly in the state agencies to evaluate and approve public and private projects and by local governments in the development of local mitigation plans.

As final products of the above methodology, it is obtained:

- Databases and updated analysis of the hazards that affect the territory of Puerto Rico.
- Geo-referenced maps of natural hazards.
- Inventory of the affected areas in total terms and by the local government.
- Inventory of critical facilities and infrastructure exposed to dangers.
- Priority ranks based on the establishment of risk levels/ vulnerability by the local government.
- Priority ranks based on the establishment of risk levels/ vulnerability for critical facilities.
- According to the CDBG-MIT the HFAR methodology is divided into three (3) phases: the spatia.

According to the CDBG-MIT the HFAR methodology is divided into three (3) phases: the spatial, which questions whether the data adequately reflects the reality of all of Puerto Rico; the temporal, which asks whether the data provides an adequate time frame to understand current and future risks; and the numerical, which questions whether the data is free of incomplete or inconsistent information.
The results of this analysis have been plotted on a map using geographic information system tools to visualize complex spatial data as one of the following data types: Point- a defined point on a map; Grid- a grid of evenly spaced horizontal and vertical lines used to identify locations on a map; and Polygon- the representation of data by drawing the outline of a figure to obtain a spatial feature. This allows one to be able to visually show which features are informing the risk frequency analysis. These mapping products are available through the CDBG-MIT Action Plan and will constitute an asset in the next update of this Plan.

3.6. Inventory of Identified Hazards

As discussed, the update process of the 2021 PRSNHMP required the incorporation of data and information produced in the last years about the identification, incidence, and other aspects of natural risks. The identification of natural hazards, included in this Chapter, has been based on the criterion of the occurrence and intensity experienced in Puerto Rico's territory during the last century, according to the information available.The classification of natural hazards discussed in this section is restricted to natural phenomena with the potential to cause significant damage to life and property.
This section identifies the risk profile of floods, landslides, extreme winds, earthquakes (liquefaction and acceleration), faults and fissures, and droughts for Puerto Rico. A description of the risk is included

and its history, risk and vulnerability assessment, and general recommendations to promote its mitigation. Of these risks, the risk of faults and fissures is presented for the first time as an individual risk in the State Mitigation Plan.

3.6.1 Floodings

The recommended flood level maps (Advisory Maps) published on March 26, 2018, were used to perform the coastal and riparian flood risk assessment. FEMA developed the maps used for Puerto Rico. The information layers of the recommended special flood hazard areas for the 100-year (1%/1 PCT) and 500-year (0.2%/2 PCT) event occurrence scenarios were used. These flood zones are categorized into: A, AE, AO, VE, and X (Recommended Base Flood Level Maps) (**Table 3-11**).

Table 3-11. Flood Zone Categories.

Category	Description
Zone - A	1% (100-year) Flood Hazard Area. Base flood level is not determined.
Zone - AE	Area of 1% (100-year) flood risk. Through a detailed study, it includes the base flood level.
Zone - AO	Areas of 1% (100-year) riverine flood hazard where the average water depth is between 1-3 feet.
Zone - VE	Coastal flood hazard area associated with " 1% (100-year) storm waves. Flood level is identified. (http://cedd.pr.gov/fema/index.php)
Zone - X	Area determined to have minimal flooding with 0.2 percent probability.

Based on the evaluation of the total flood extent (riparian and coastal) as defined in the information layer presented in the flood level maps (Advisory Map) for a 100-year flood scenario (1%) and the evaluation of demographic parameters for 2018, the following is identified:

- Approximate 697,925 people located in flood zones (riverine and coastal) in Puerto Rico for 2018 (flood zones A, AE, AO, VE).
- Approximate 660,981 people located in non-coastal flood zones by 2018 (flood zones A, AE, AO).
- Approximate 36,994 people located in coastal flood zones by 2018 (flood zone VE).
- Approximate 2,689,016 people located in a minimum flood zone for 2018 (flood zone X).

This means that of the flood categories presented, flood zone X has the highest population located in it (79% of the population) (Figure 3-9). This category represents the flood zone with the lowest risk of flooding. On the other hand, approximately 21% of the island's population is in a flood hazard zone. It is important to note that even if the island has 14% of flood zones, these cannot be underestimated due to their impact on life and property. Of the defined flood zones, the category that defines non-coastal flood risk zones (riparian) is the one with the largest number of people exposed. It is followed by the coastal flood zone with an exposed population of 36,944.

The ten (10) municipalities with the highest exposure to non-coastal and coastal flood risk are Carolina (76,829), San Juan (71,148), Ponce (54,146), Toa Baja (46,272), Bayamón (25,632), Cataño (22,696), Mayagüez (22,642), Loíza (20,684), Caguas (20,374) and Humacao (18,332). See Figure 3-10. Of these municipalities, the municipality of Loíza presents the largest amount of population (91.9 % of its total population) exposed to riverine and coastal flooding for 2018 **(Figure 3-10)**. Cataño and Toa Baja's municipalities are the other municipalities that present high population exposure to flood risk with 89.8% and 62.1%, respectively ().

Figure 3-9. Identification of flood zones in Puerto Rico for a 1% occurrence scenario (100-year/1 PCT). Reference: Puerto Rico advisory map 2018 flood information layer.

Table 3-12. Population exposed to flooding (non-coastal and coastal) (flood zones A, AE, AO, and VE) in Puerto Rico, 2018, 1% scenario (100-year/ 1PCT) (Reference: 1PCT flood plain Advisory Map 2018 and Community Survey 2018)

RANK DETERMINATION BY POTENTIALLY AFFECTED POPULATION RISK: Non-coastal and coastal flooding 1% (100 years/ 1 PCT)				
Municipality	**Total Population**	**Absolute Population**	**Percentage of the municipality in Flood Zone**	**Range**
Carolina	157,453	76,829	39.1%	1
San Juan	344,606	71,148	18.6%	
Ponce	143,926	54,146	19.6%	
Toa Baja	79,726	46,272	62.1%	
Bayamón	182,955	25,632	10.5%	5
Cataño	24,888	22,696	89.8%	
Mayagüez	77,255	22,642	12.9%	
Loíza	26,463	20,684	91.9%	
Caguas	131,363	20,374	10.0%	
Humacao	53,466	18,332	30.0%	

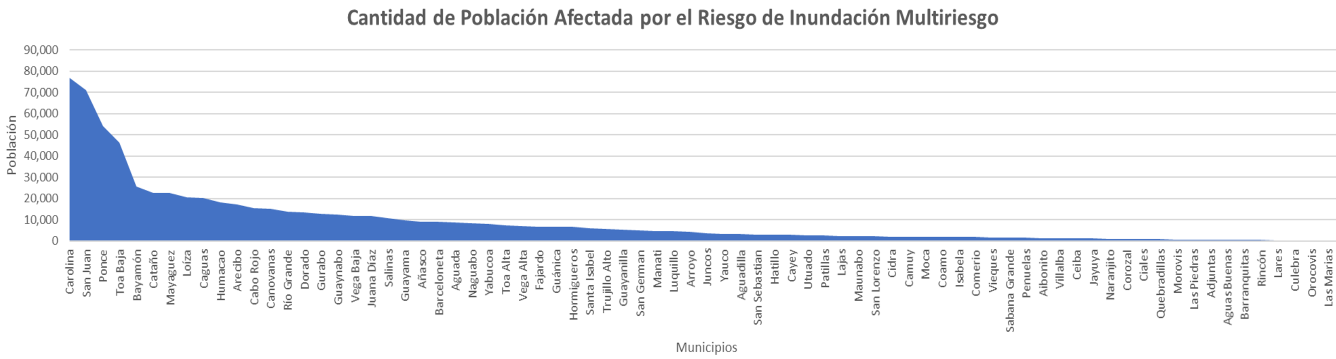
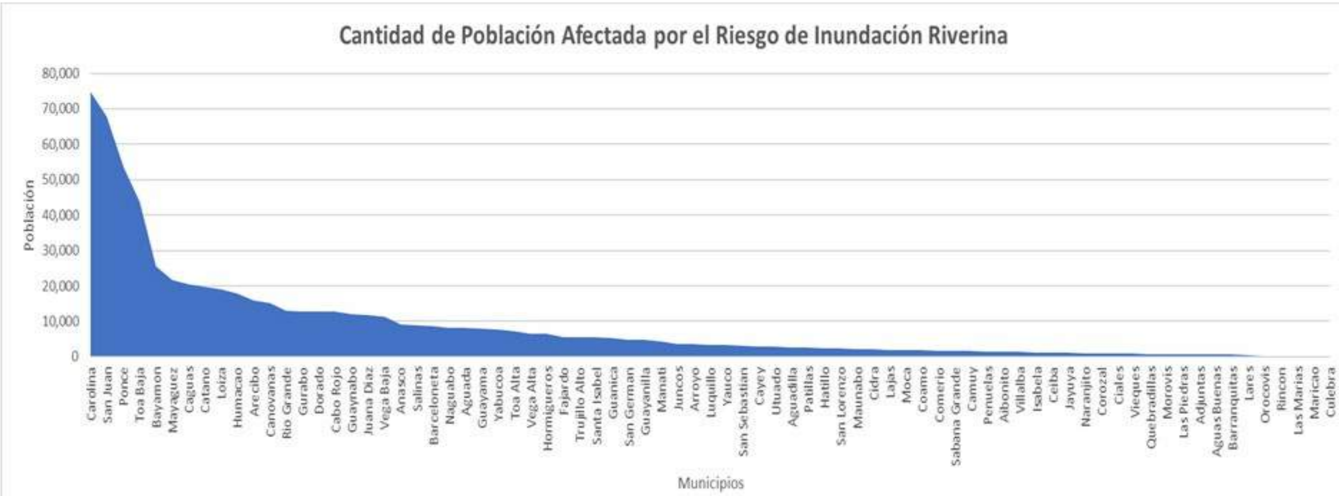


Figure 3-10. Number of population exposed to flood risk (riparian and coastal) for a 1% (100-year/1PCT) occurrence scenario by municipality, 2018.

The ten (10) municipalities with the highest number of populations affected by the non-coastal flooding reach (from highest to lowest occurrence) in the 1% occurrence scenario (100 years/1 PCT) are: Carolina (74,783); San Juan (67,771); Ponce (53,626); Toa Baja (43,595); Bayamón (25,632); Mayagüez (21,710); Caguas (20,374); Loíza (19,122) and Humacao (17,754). See **Figure 3-11**. Of these, the municipalities of Cataño, Loíza, and Toa Baja present the greatest risk of non-coastal flooding, with 89%, 85%, and 61% of the municipalities' area exposed to flooding, respectively (**Table 3-13**)

Table 3-13. Population exposed to non-coastal flooding (flood zones A, AE, and AO) in Puerto Rico, 2018, 1% scenario (100-year/ 1PCT) (Reference: 1PCT flood plain Advisory Map 2018 and Community Survey 2018).

RANK DETERMINATION BY POTENTIALLY AFFECTED POPULATION RISK: Non-coastal flooding 1% (100 years/1 PCT)				
Municipality	**Total Population**	**Affected Population**	**Percentage of the municipality in Flood Zone**	**Range**
Carolina	157,453	74,783	39.1%	1
San Juan	344,606	67,771	18.6%	
Ponce	143,926	53,626	19.4%	
Toa Baja	79,726	43,595	61.1%	
Bayamón	182,955	25,632	10.5%	5
Mayagüez	77,255	21,710	12.7%	
Caguas	131,363	20,374	10.0%	
Cataño	24,888	19,806	85.0%	
Loíza	26,463	19,122	89.0%	
Humacao	53,466	17,754	29.2%	



The ten (10) municipalities with the highest population exposed to coastal flooding within a 1% occurrence scenario (100 years/1 PCT) are: San Juan (3,377), Cataño (2,890), Cabo Rojo (2,813), Toa Baja (2,678), Carolina (2,047), Salinas (2,037), Guayama (1,839), Loíza (1,562), Arecibo (1,349) and Guánica (1,297) (**Figure 3-12, Table 3-14**).

Table 3-14. Population exposed to coastal flooding (VE flood zones) in Puerto Rico, 2018, 1% (100-year/ 1PCT)scenario. (Reference: 1PCT flood plain Advisory Map 2018 and Community Survey 2018).

RANK DETERMINATION BY POTENTIALLY AFFECTED POPULATION RISK: Non-coastal and coastal flooding 1% (100 years/ 1 PCT)				
Municipality	**Total Population**	**Absolute Population**	**Percentage of the municipality in Flood Zone**	**Range**
San Juan	344,606	3,377	0.6%	1
Cataño	24,888	2,890	4.7%	
Cabo Rojo	49,005	2,813	2.2%	
Toa Baja	79,726	2,678	1.0%	
Carolina	157,453	2,047	0.2%	5
Salinas	28,633	2,037	1.8%	
Guayama	41,706	1,839	1.4%	
Loíza	26,463	1,562	2.9%	
Arecibo	87,242	1,349	0.5%	
Guánica	16,783	1,297	1.1%	

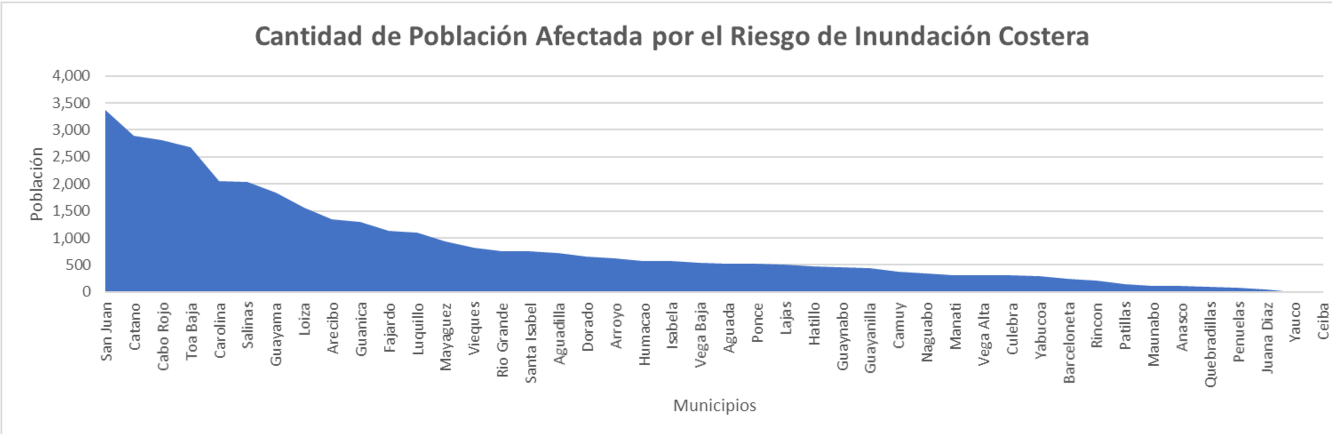


Figure 3-12. Number of population exposed to (coastal) flood risk for a 1% (100-year/1PCT) occurrence scenario by municipality, 2018.

The island's population's exposure to flood risk (non-coastal/riparian) is also identified for an event occurrence scenario of 0.2% (500 years/2 PCT). According to this scenario there are a total of 793,202 individuals exposed to flood risk in Puerto Rico for 2018. **(Figure 3-13)**. The municipalities with the largest population exposed to flooding from a 0.2% occurrence scenario are: Carolina (83,554), San Juan (82,683), Ponce (59,560), Toa Baja (45,642), Bayamón (35,111), Caguas (25,381), Mayagüez (22,394), Cataño (20,807), Loíza (19,067), and Humacao (17,653) **(Table 3-15)**. If we compare the amount of population exposed to flooding in the 1% scenario, we find that in the 0.2% scenario, the amount of population exposed increases in most of the municipalities. **(Figure 3- 14).**

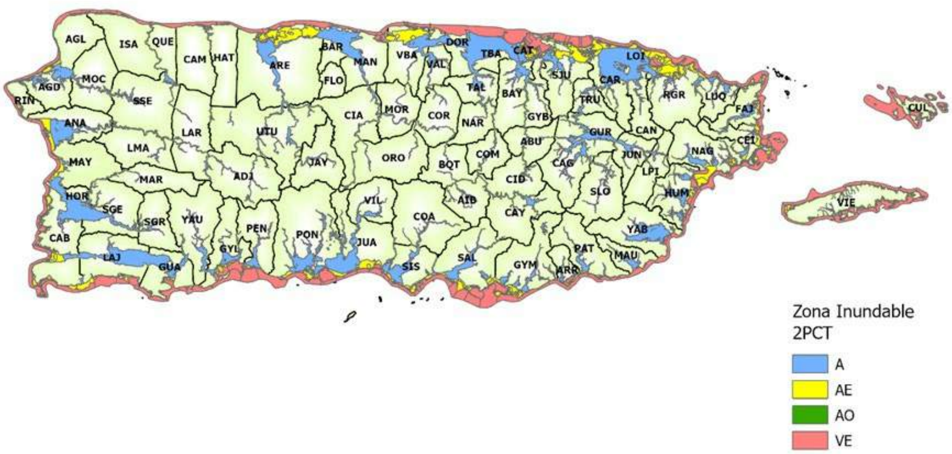


Figure 3-13. Identification of flood zones in Puerto Rico for a 0.2% (500-year/0.2 PCT) occurrence scenario. Reference: Puerto Rico advisory map 2018 flood information layer.

Table 3-15. Population exposed to non-coastal flooding (flood zones A, AE, and AO) in Puerto Rico, 2018, 0.2% scenario (500-year/ 0.2PCT) (Reference: 1PCT flood plain Advisory Map 2018 information layer and Community Survey 2018).

RANK DETERMINATION BY POTENTIALLY AFFECTED POPULATION RISK: Non-coastal and coastal flooding 1% (100 years/ 1 PCT)				
Municipality	**Total Population**	**Affected Population**	**Percentage of the municipality in Flood Zone**	**Range**
Carolina	157,453	83,554	44.2%	1
San Juan	344,606	82,683	21.7%	
Ponce	143,926	59,560	18.5%	
Toa Baja	79,726	45,642	62.0%	
Bayamón	182,955	35,111	14.5%	5
Caguas	131,363	25,381	12.1%	
Guayama	77,255	22,394	13.4%	
Cataño	24,888	20,807	79.1%	
Loíza	26,463	19,067	84.7%	
Humacao	53,466	17,653	27.5%	

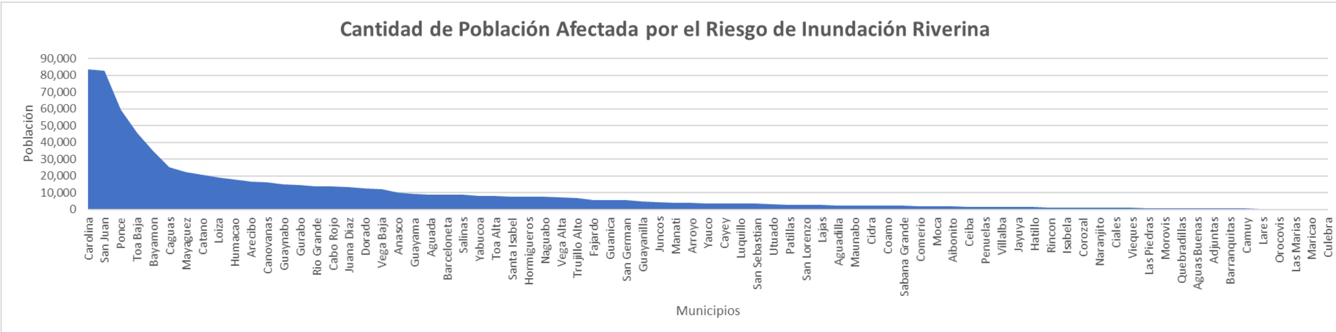


Figure 3-14. Number of population exposed to flood risk (non-coastal) for a 0.2% (500-year/0.2 PCT) occurrence scenario by municipality, 2018.

The municipalities with the highest population exposed to coastal flooding at a 0.2% occurrence scenario are: San Juan (5,395), Cataño (3,844), Toa Baja (3,827), Cabo Rojo (3,693), Loíza (3,215), Humacao (2,928), Salinas (2,623), Dorado (2,445), Carolina (2,222) and Guayama (1,932) **(Table 3-16).** In this scenario, the municipality of Dorado appears with a population exposed to coastal flooding. If we compare the amount of population exposed to flooding in the 1% scenario, we find that in the 0.2% scenario, the amount of population exposed increases in most of the municipalities. (**Figure 3-15**).

Table 3-16. Population exposed to coastal flooding (VE flood zones) in Puerto Rico, 2018, 0.2% scenario (500 years/ 0.2PCT) (Reference: 1PCT flood plain Advisory Map 2018 and Community Survey 2018).

RANK DETERMINATION BY POTENTIALLY AFFECTED POPULATION RISK: Coastal flooding 0.2%(500 years/0.2 PCT)				
Municipality	**Total Population**	**Absolute Population**	**Percentage of the municipality in Flood Zone**	**Range**
San Juan	344,606	5,395	0.9%	1
Cataño	24,888	3,844	19.5%	
Toa Baja	79,726	3,827	2.7%	
Cabo Rojo	49,005	3,693	3.0%	
Loíza	26,463	3,215	9.9%	5
Humacao	53,466	2,928	5.4%	
Salinas	28,633	2,623	4.0%	
Dorado	37,208	2,445	6.0%	
Carolina	157,453	2,222	0.2%	
Guayama	41,706	1,931	1.3%	

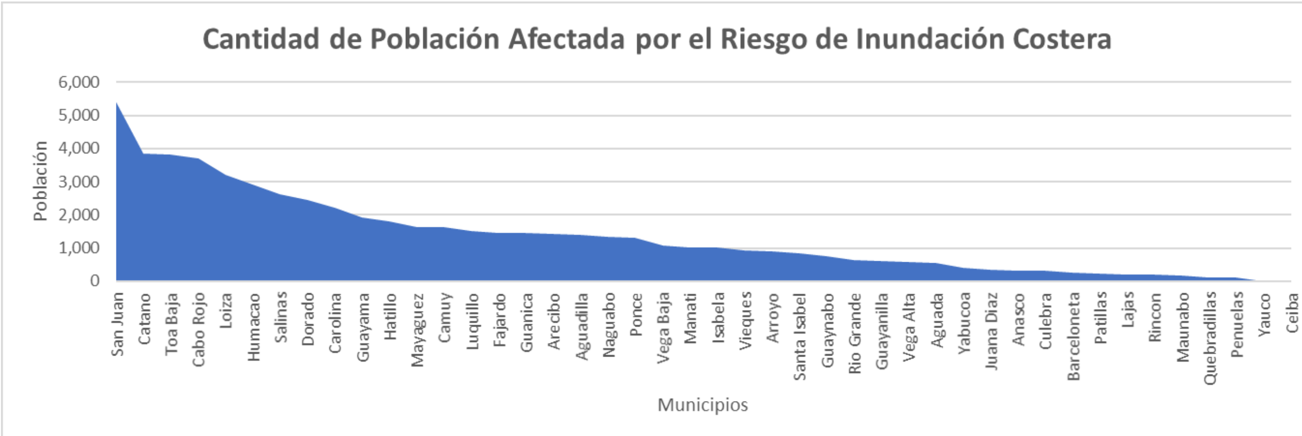


Figure 3-15. Number of population exposed to (coastal) flood risk for a 0.2% (500-year/0.2 PCT) occurrence scenario by municipality, 2018.

Population exposure to flood risk (non-coastal and coastal) by demographic and socioeconomic variables (population aged 16 and under, population aged 65 and over, households with income under $10,000, population with disabilities, and female heads of household).

This section describes and analyzes the number of vulnerable people within the 100-year (1PCT) and 500-year (.2 PCT; 0.2%) major coastal and riverine flood hazard areas at the state and municipal levels. Five (5) population variables were used to conduct this analysis: population 16 years of age or younger, population 65 years of age or older, households with income less than $10,000, disabled population, and female head of household for the 2018 period. The assessment of these demographic and socioeconomic variables present population characteristics that are traditionally associated with poverty levels (Santiago et al. 2020). This metric may help identify populations that do not possess sufficient resources to respond to a risk and/or disaster event adequately. These were evaluated for the 100- and 500-year scenario for coastal and riverine floods).

The ten (10) municipalities with the highest number of a vulnerable population (population 16 years of age or younger, people 65 years of age or older, households with incomes below $10,000, population with disabilities, and female household dependents) exposed to non-coastal flooding in a 100-year scenario (1%) are: risk are: Carolina (57,903), San Juan (57,576), Ponce (44,182), Toa Baja (31,502), Mayagüez (20,555), Bayamón (19,973), Caguas (16,649), Cataño (16,099), Loíza (14,828) and Cabo Rojo (2,544) (**Table 3-17**). Of this population, the groups of people over 65 and people with disabilities are the most frequent demographic categories exposed to the non-coastal flood event for a 100-year scenario. This finding shows the importance of prioritizing the assistance processes to this type of population in a flooding event on the island.

Table 3-17. Population (Population aged 16 and under; Population aged 65 and over; Households with income less than $10,000; Population with disabilities; Female head of household) exposed to non-coastal flooding (flood zones A, AE, AO) in Puerto Rico, 2018, 1% scenario (100-year/ 1 PCT) (Reference: Information layer 1PCT flood plain Advisory Map 2018 and Community Survey 2018).

POPULATION AFFECTED BY RIVERINE FLOODING, 1% occurrence scenario (100years/1PCT)						
Municipality	Population 16 years of age or younger	Population aged 65 and over	Households with income less than $10,000	Population with disabilities	Women in charge of the household	Total, of vulnerable people
Carolina	11,677	16,713	4,998	16,684	7,831	57,903
San Juan	12,976	12,762	10,725	12,952	8,161	57,576
Ponce	9,720	11,368	7,604	9,563	5,927	44,182
Toa Baja	8,036	7,895	3,159	8,898	3,514	31,502
Mayagüez	4,572	4,120	3,852	5,380	2,631	20,555
Bayamón	3,528	5,560	2.015	6,500	2,370	19,973
Caguas	3,324	4,249	1,781	5,206	2,089	16,649
Cataño	3,656	3,602	2,248	4,521	2,072	16,099
Loíza	3,587	3,162	2,162	3,925	1,992	14,828

The ten (10) municipalities with the highest number of vulnerable population (population 16 years of age or younger, population 65 years of age or older, households with incomes below $10,000, population with disabilities, and female household dependents) exposed to coastal flooding in a 100-year scenario (1%) are: Cataño (2,316), San Juan (2,236), Toa Baja (1,971), Cabo Rojo (1,969), Salinas (1,613); Guayama (1,413); Carolina (1,251); Loíza (1,238), Guánica (1,212) and Arecibo (1,128) (Table 3-18). The population over 65 and with disabilities is the most common population category among the selected demographic variables.

Table 3-18. Population (Population aged 16 and under; Population aged 65 and over; Households with income less than $10,000; Population with disabilities; Female head of household) exposed to coastal flooding (VE flood zones) in Puerto Rico, 2018, 1% scenario (100 years/ 1 PCT) (Reference: 1PCT flood flood plain Advisory Map 2018 and Community Survey 2018).

POPULATION (Population aged 16 and under; Population aged 65 and over; Households with income under $10,000; Population with disabilities; Female heads of household) AFFECTED BY COASTAL FLOODING 1% (100 years/1PCT)						
Munici-pality	Population 16 years of age or younger	Popula-tion aged 65 and over	Households with income less than $10,000	Population with dis-abilities	Women in charge of the house-hold	Total, of vulnerable people
Cataño	503	529	308		276	2,316
San Juan	406	784	317	462	234	2,236
Toa Baja	399	599	220	515	238	1,971
Cabo Rojo		559	287	558		1,969
Salinas	381	347	288	414		1,613
Guayama	353	248	218	470		1,413
Carolina		643		371		1,251
Loíza	299	260	211	293		1,238
Guánica	231			414	101	1,212
Arecibo	202	353		260		1,128

The risk assessment of the population vulnerable to non-coastal flood risk for an event occurrence scenario of 0.2% (500 years) shows that the municipalities with the most exposed population are: San Juan, Carolina, Ponce, Toa Baja, Bayamón, Mayaguez, Caguas, Cataño, Loíza, and Humacao. In coastal flood risk, the municipalities with the most vulnerable population are San Juan, Cataño, Toa Baja, Cabo Rojo, Loiza, Salinas, Dorado, Humacao, Guayama, Carolina. (**Table 3-19**).

Table 3-19. Population. (Population aged 16 years or younger; Population aged 65 years or older; Households with income less than $10,000; Population with disabilities; Female head of household) exposed to non-coastal flooding (flood zones A, AE, AO) in Puerto Rico, 2018, 0.2% scenario (500-year/ 0.2 PCT) (Reference: 0.2PCT flood plain Advisory Map 2018 and Community Survey 2018 information layer).

POPULATION AFFECTED BY RIVERINE FLOODING, scenario of occurrence 0.2% (500 years/0.2 PCT)						
Munici-pality	**Population 16 years of age or younger**	**Population aged 65 and over**	**Households with income less than $10,000**	**Popula-tion with disabili-ties**	**Women in charge of the house-hold**	**Total, of vulnera-ble people**
San Juan	15,087	15,993	12,825	15,699	9,660	69,264
Carolina	13,069	18,491	5,470	18,303	8,751	64,534
Ponce	10,670	12,864	8,182	10,682	6,430	48,828
Toa Baja	8,444	8,338	3,301	9,320	3,635	33,038
Bayamón	4,849	7,388	2,899	8,871	3,302	27,309
Mayagüez	4,617	4,299	3,934	5,523	2,665	21,038
Caguas	4,165	5,323	2,207	6,484	2,623	20,802
Cataño	3,879	3,736	2,361	4,720	2,202	16,898
Loíza	3,636	3,136	2,233	3,853	2,025	14,883
Humacao	3,109	3,427	1,631	1,987	1,385	11,539

Table 3-20. Population (Population aged 16 and under; Population aged 65 and over; Households with income less than $10,000; Population with disabilities; Female head of household) exposed to coastal flooding (VE flood zones) in Puerto Rico, 2018, 0.2% scenario (500 yr/ 0.2 PCT) (Reference: 0.2 PCT information layer plain flood Advisory Map 2018 and Community Survey 2018).

POPULATION AFFECTED BY COASTAL FLOODING 0.2% (500 years/0.2PCT)						
Municipality	Population 16 years of age or younger	Population aged 65 and over	Households with income less than $10,000	Population with disabilities	Women in charge of the household	Total, of vulnerable people
San Juan	670	1,244	591	800	413	3,718
Cataño	678	718	417	935		3,118
Toa Baja	554	871	308	738	345	2,816
Cabo Rojo	527	710	373	716	218	2,544
Loíza	579	534	366	665	333	2,477
Salinas	489	450	379	539	261	2,118
Dorado	470	445		364	202	1,631
Humacao	444	507	170	289		1,609
Guayama	371	260	229	493		1,483
Carolina		703		395		1,357

Exposure of critical infrastructure (PRASA's water lines, sanitary, pumping), Highways (General), State Highways, PREPA transmission centers, plants, and substations; Cellular Antennas; Schools and Shelters) to the risk of flooding (non-coastal and coastal).

The ten (10) municipalities with the highest number of vulnerable population (population 16 years of age or younger, population 65 years of age or older, households with incomes below $10,000, population with disabilities, and female household dependents) exposed to coastal flooding in a 100-year scenario (1%) are: Cataño (2,316), San Juan (2,236), Toa Baja (1,971), Cabo Rojo (1,969), Salinas (1,613); Guayama (1,413); Carolina (1,251); Loíza (1,238), Guánica (1,212) and Arecibo (1,128) **(Table 3-18).** The population over 65 and with disabilities is the most common population category among the selected demographic variables.

Of the roads identified, 50.4% of state highways are in riparian and coastal flood risk zones (**Table 3-21**). Of these roads in flood risk zones, 4.36% are in VE flood zones for a 100-year event scenario.

Of the total number of substations of the Puerto Rico Electric Power Authority (PREPA) located on the island, 89% are in flood zones (**Table 3-22**). Of the electric power generating plants, 62% of these structures are in flood risk zones. There are no plants located in flood zone VE. On the other hand, 90% of PREPA's transmission centers are in flood zones.

Regarding the infrastructure of PRASA, specifically the water lines, 69% of these lines pass through flood risk zones. Two percent of this infrastructure is in flood zone VE (Table 3-23). Approximately 75% of the PRASA's sanitation service is in flood risk areas (Table 3-24). Two percent of these units are in flood zone VE. **Table 3-21**. Critical infrastructure (State Highways, exposed to non-coastal flood risk, 1% scenario (100 years/ 1 PCT) (Reference: 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018).

Table 3-21. Critical infrastructure (State Highways, exposed to non-coastal flood risk, 1% scenario (100 years/ 1PCT) (Reference: 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018).

INFRASTRUCTURE IN FLOODPROOF ZONE .01pct: State Roads			
	Flood Zone	No. of Roads Affected	Total Meters
1	A	1,995	1,054,696.824
	AE	395	118,397.699
	AO		28,453.190
	VE		46,639.254
5	X	2,521	287,040.133

Table 3-22. Critical infrastructure (Substations, Plants, Transmission Centers Electric Power Authority (EPA) exposed to flooding at 1% scenario (100 years/ 1 PCT) (Reference: 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018).

INFRASTRUCTURE IN FLOODPROOF AREA 1% (100 years/1 PCT) PR Electric Power Authority (substations, plants, transmission centers)				
	Flood Zone	Number of substations	Number of Plants	Number of Transmission Centers
1	A		1	
	AE			0
	AO	1	0	0
	VE	1	0	0
5	X			1

Table 3-23. Critical infrastructure (PRASA water lines) exposed to flooding at 1% (100-year/ 1 PCT) scenario (Reference: 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018).

INFRASTRUCTURE IN FLOOD ZONE 1PCT: PR Aqueduct and Sewer Authority			
	Flood Zone	PRASA Water Lines	Linear Meters
1	A	24,150	2,448,004.979
	AE	5,259	391,725.117
	AO		48,319.340
	VE	549	74,929.880
5	X	13,416	699,374.267

Table 3-24. Critical infrastructure (Aqueduct and Sewer Authority (AAA) sanitary lines) exposed to flooding at 1% scenario (100 years/ 1 PCT) (Reference: Information layer 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018).

INFRASTRUCTURE IN FLOOD ZONE 1 PCT: PR Aqueducts and Sewer Authority			
	Flood Zone	PRASA Sanitary	Linear Meters
1	A	32,398	1,633,253.99
	AE	6,592	291,196.401
	AO	931	45,347.284
	VE	555	23,049.659
5	X	13,370	468,274.700

Approximately 69% of the PRASA's Pumping System units are in a flood risk zone (Table 3-25). Five percent of this infrastructure is in flood risk zone VE.

Table 3-25. Critical infrastructure (Aqueduct and Sewer Authority (AAA) Sanitary Pumping System) exposed to flooding at 1% (100-year/ 1 PCT) scenario (Reference: 0.2 PCT information layer flood plain Advisory Map 2018 and Community Survey 2018).

INFRASTRUCTURE IN FLOOD ZONE 1PCT: Water and Sewer Authority			
	Flood Zone	Sanitary Pumping System	Linear Meters
1	A	654	232,739.048
	AE	951	51,338.149
	AO		3,547.535
	VE		11,072.181
5	X	762	60,858.103

Table 3-26. Critical infrastructure (shelters) exposed to flooding at 1% scenario (100-year/ 1 PCT) (Reference: 0.2 PCT information layer flood plain Advisory Map 2018 and Community Survey 2018). * 2018 data

INFRASTRUCTURE IN FLOOD ZONE 1 PCT: Shelters		
	Flood Zone	Number of Affected Shelters
1	A	
	AE	5
	AO	
	VE	
5	X	1

Table 3-27. Critical infrastructure (public system schools) exposed to flooding at 1% (100-year/ 1 PCT) scenario (Reference: 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018). * 2018 data

INFRASTRUCTURE IN FLOODPROOF AREA .01PCT: Schools		
	Flood Zone	Number of Schools Affected (Esti-mated)
1	A	227
	AE	
	AO	
	VE	
5	X	0

Table 3-28. Critical infrastructure (State Highways) exposed to flooding at 0.2% (500-year/ 0.2 PCT) scenario (Reference: 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018). * 2018 data

INFRASTRUCTURE IN FLOOD ZONE 0.2 PCT: State Roads			
	Flood Zone	No. of Roads Affected	Linear Meters
1	A	1.824	1.195.413,962
	VE	744	260.479,245
	VE		79.454,511

Table 3-29. Critical Infrastructure (substations, plants, and transmission centers) exposed to flooding at 0.2% (500-year/ 0.2 PCT) scenario (Reference: 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018). * 2018 data+++

INFRASTRUCTURE IN FLOOD ZONE 0.2 PCT: Electric Power Authority				
	Flood Zone	Number of substations	Number of Plants	Number of Transmission Centers
1	A			
	AE		5	1
	AO	0	0	0
	VE		1	0
5	X	0	0	0

Information on the exposure of infrastructure within 500-year flood hazard zones (2%/0.2 PCT) can be found in the following tables.

Table 3-30. Critical infrastructure (AAA water lines) exposed to flooding at 0.2% (500-year/ 0.2 PCT) scenario (Reference: 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018 information layer). * 2018 data 2018). * 2018 data

INFRASTRUCTURE IN FLOODPROOF ZONE 0.2PCT: Water and Sewer Authority			
	Flood Zone	AAA Water Lines	Linear Meters
1	A	25,492	2.721.296,253
	AE	10,120	798.986,018
	AO	0	0
	VE	1,288	143,216,872
5	X	0	0

Table 3-31. Critical infrastructure (AAA Sanitary Service) exposed to flooding at 0.2% (500 years/ 0.2 PCT) scenario (Reference: 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018 information layer).data 2018). * 2018 data

INFRASTRUCTURE IN FLOODPROOF ZONE .02PCT: Water and Sewer Authority			
	Flood Zone	AAA Sanitary	Linear Meters
1	A	34,149	1,808,418,238
	AE	12,950	607.737,643
	AO	0	0
	VE	1,714	75,352,971
5	X	0	0

Table 3-32. Critical infrastructure (PRASA Sanitary Pumping System) exposed to flooding at 0.2% (500 years/ 0.2 PCT) scenario (Reference: 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018).

INFRASTRUCTURE IN FLOOD ZONE 0.2 PCT: Water and Sewer Authority			
	Flood Zone	Sanitary Pumping System	Linear Meters
1	A	539	226.300,178
	AE	1,298	110,131,485
	AO	0	0
	VE	162	24.075,612
5	X	0	0

Table 3-33. Critical infrastructure (Communications) exposed to flooding at 0.2% (500 years/ 0.2 PCT) scenario (Reference: 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018).

INFRASTRUCTURE IN FLOODPROOF AREA 0.2PCT: Communications		
	Flood Zone	Antennas
1	A	5
	AE	
	AO	0
	VE	1
5	X	0

Table 3-34. Critical infrastructure (Communications) exposed to flooding at 0.2% scenario (500 years/ 0.2 PCT) (Reference: Information layer 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018).

INFRASTRUCTURE IN FLOODPROOF AREA 0.2PCT: Communications		
	Flood Zone	Antennas
1	A	
	AE	
	AO	0
	VE	1
5	X	0

Table 3-35. Critical infrastructure (schools) exposed to flooding at 0.2% (500 years/ 0.2 PCT) scenario (Reference: 0.2 PCT flood plain Advisory Map 2018 and Community Survey 2018 information layer).

INFRASTRUCTURE IN FLOOD ZONE 0.2 PCT: Schools		
	Flood Zone	Antennas
1	A	266
	AE	
	AO	0
	X	0
5	VE	

To complement the analysis, CDBG-MIT categorizes the 100-year flood as the 100-year flood in that context is different than how the state plan addresses it. CDBG-MIT used FEMA data and its categories to determine the characterization of the national flood risk dataset for the U.S. through a Map Service Center available online. Thus, the entire Special Flood Hazard Area dataset was downloaded, which represents flood hazards with a probability of occurrence of zero point zero one (0.01) in a particular year, commonly referred to as a "100-year flood" or one percent (1%) annual chance of flooding. The potential for flood risk is present in every municipality, but is considerably higher in the municipalities of the considerably higher in municipalities in the north-central, northeast, east, south-central, southeast, and west regions, south-central, southeastern and western regions.

The map of 100-year Flood Boundary Flood Zones on the following page shows the potential for flooding in each municipality. The map of 100-year Flood Boundary Zones on the following page categorizes each hexagonal grid zero-point-five (0.5) square miles based on the amount of land area that lies within the 100-year Flood Boundary Zone. area that falls within the FEMA 100-Year Rainfall Flood Boundary Zone, using a FEMA 100-Year Rainfall Flood Boundary Zone, using an equal interval classification. As opposed to using the perimeter of the floodplain, this map allows for a comparison of area along the entire area comparison across the entire Island. The northwestern municipalities appear to have relatively less potential for flood risk than most other units throughout the Island. units throughout the island. In addition, inland municipalities such as Caguas, Gurabo and Juncos have more areas at risk of flooding have more areas at risk of flooding than most of their neighboring municipalities.

3.6.2. Landslides.

The physical characterization of the landslide risk profile for Puerto Rico is performed using data, information, and databanks already published by the U.S. Federal Geological Survey (USGS), Department of Geology, University of Puerto Rico, Mayagüez Campus (UPRM). These evaluated the areas most affected by landslides using post-Hurricane Maria satellite imagery and aerial imagery between September 26 to October 8, 2017. To get an idea of the municipalities' physical vulnerability, they used the landslide susceptibility layer and landslide density data from Stephen Hughes & Schulz (2020). On the map, they divided the Island into 2km x 2km grids and classified these into no landslides (NLS), 1 - 25 landslides as low landslide density (LLD), or in the case of 25 landslides or more as high landslide density (HLD). **(Figure 3-16).**

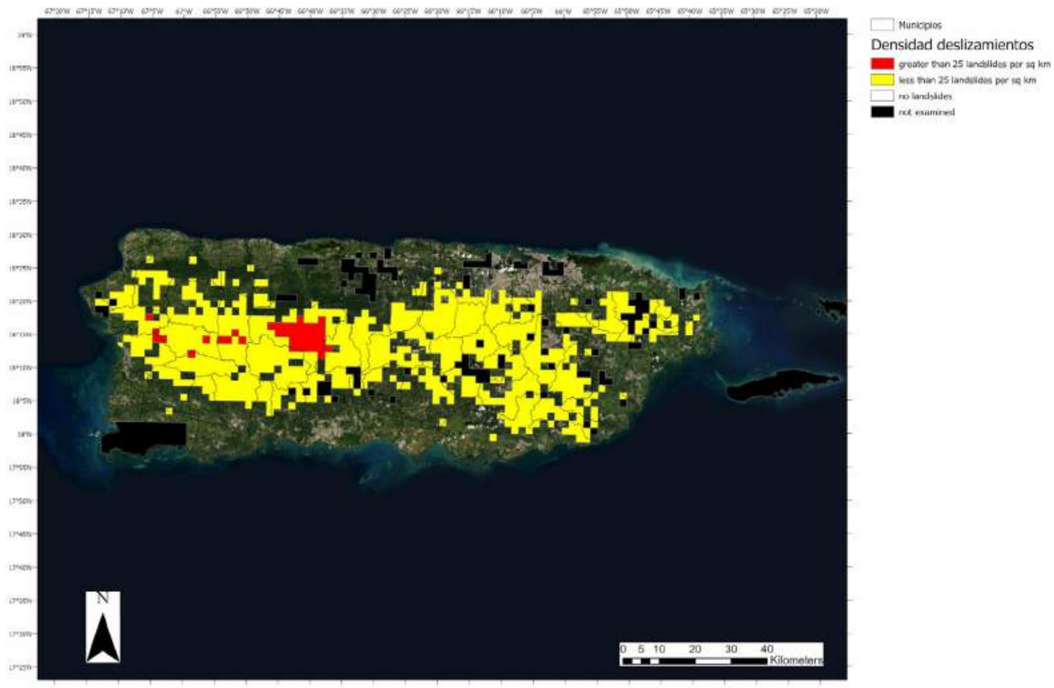


Figure 3-16. Density of landslides in Puerto Rico. .(UPRM, USGS & Natural Hazards Center, 2020). The information collected was validated with field trips and helicopter flights to identify the most landslide- prone areas in Puerto Rico. The location of landslides after Hurricane Maria is also part of this analysis. UPRM conducted the landslide assessment using remote sensing and field assessments.

According to the UPRM study, more than 70,000 landslides were identified after Hurricane Maria. The location of each of the reported landslides can be seen in **Figure 3-17.** The highest concentrations of landslides are found in the mountainous area of Puerto Rico.

In early 2020, the USGS completed a study of rain-induced landslides in Puerto Rico. The report summarizes. The report summarizes the creation of a new high-resolution model of rain-induced landslide susceptibility on the island. The report summarizes the creation of a new high-resolution rainfall landslide susceptibility model for the Island. The Island of Puerto Rico was classified on the five (5) pixel scale five (5) meter pixel scale under the categories of Low, Moderate, High, Very High, and Extremely High susceptibility, High, Very High, and Extremely High susceptibility to landslides during and shortly after an after heavy rainfall, such as those occurring during tropical cyclones. Zero-point-five (0.5) square mile hexagonal grid susceptibility index (SI) values were summarized and a focus was generated on the values of landslide values was generated.[20]

[20] CDBG-MIT PRSHNMP Evaluación de Riesgo pag.41

According to the CDBG-MIT Action Plan, there are municipalities like Utuado (69 mi2), Adjuntas (45.8 mi2) and Ponce (40.6 mi2) have the most land in the "extreme" landslide susceptibility category. However, in other towns, more than sixty percent (60%) of their total area is in the "extreme" susceptibility category, as in the case of 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%).[21]

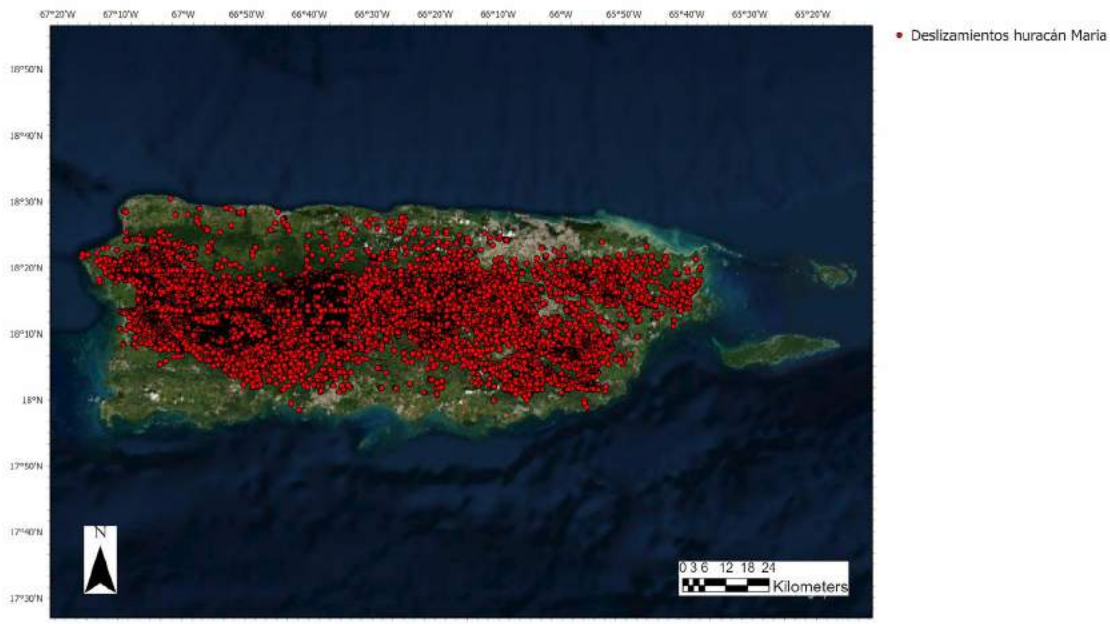


Figure 3-17. Location of Post Maria landslide occurrence. (UPRM, USGS & Natural Hazards Center, 2020).

Physical Vulnerability Exposure to Landslides.

This section evaluates landslide exposure and risk in Puerto Rico based on the scenario of landslides produced by extreme precipitation events associated with cyclonic systems such as hurricanes. It is important to note that, although this assessment uses the scenario of Hurricane Maria producing extreme rainfall events, this type of precipitation could occur in the scenario of other tropical cyclonic events.

The landslide susceptibility variable is used to determine the most likely areas where a landslide could occur and threaten people's lives and property. Given this scenario, the report published in 2020 by the Landslides Hazards Program of the USGS and UPRM entitled “Landslides Triggered by Hurricane Maria: Assessment of an Extreme Event in Puerto Rico” shows the relative susceptibility to landslides

[21] CDBG-MIT PRSHNMP Evaluación de Riesgo pag.42

Event in Puerto Rico" shows the relative susceptibility to landslides after extreme rainfall events. In this analysis,a high spatial resolution map was generated that citizens and government agencies can use to know where the places susceptible to landslides are. The geospatial data that define the reported landslide areas' susceptibility include assessing the slope and curvature of the land surface, mean annual precipitation, proximity to roads, land cover, and soil moisture.

Figure 3-18 presents the scenario of physical susceptibility to landslides caused by precipitation events. The susceptibility level is categorized into Low, Moderate, High, Very High and Extremely High.

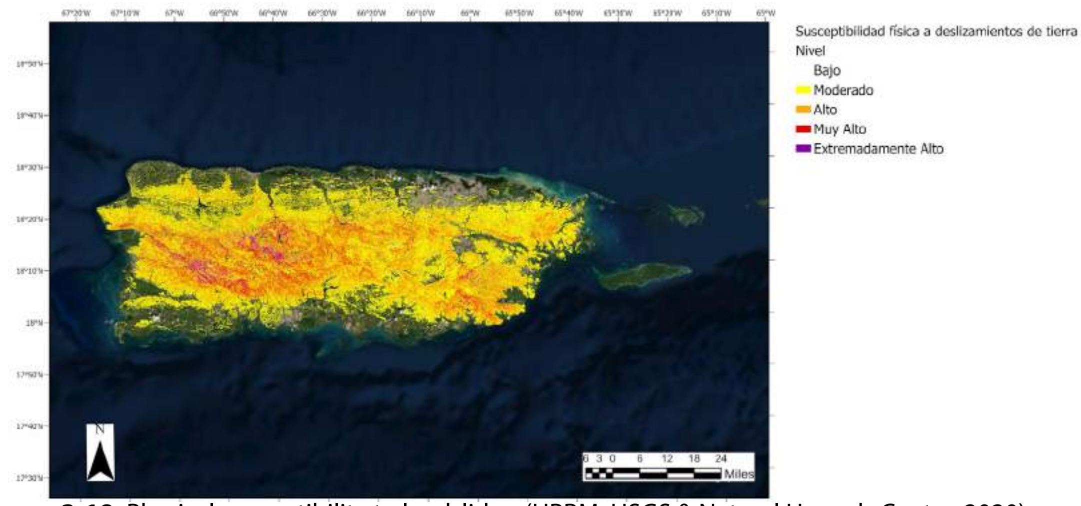


Figure 3-18. Physical susceptibility to landslides; (UPRM, USGS & Natural Hazards Center, 2020).

The municipalities affected with the greatest number of landslides after Hurricane Maria were Utuado, Maricao, Jayuya, Lares and Las Marías **(Figure 3-19)**. These municipalities are in the mountainous-central zone of Puerto Rico.

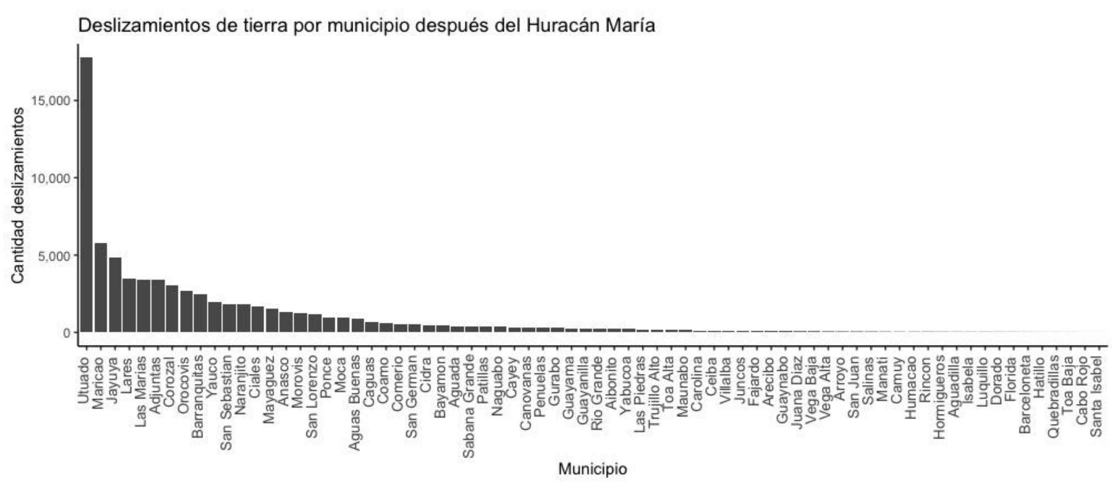


Figure 3-19. Graph of Landslides by Municipality.

The five municipalities with the largest areas susceptible to landslides are Utuado, Adjuntas, Ponce, Orocovis and Ciales (**Figure 3-20**). It is important to note that these municipalities share similar geographic and geological aspects, which is an inherent characteristic of landslides. This will have an effect throughout the sections, since the information will redound in the analysis of the different vulnerable population variables.

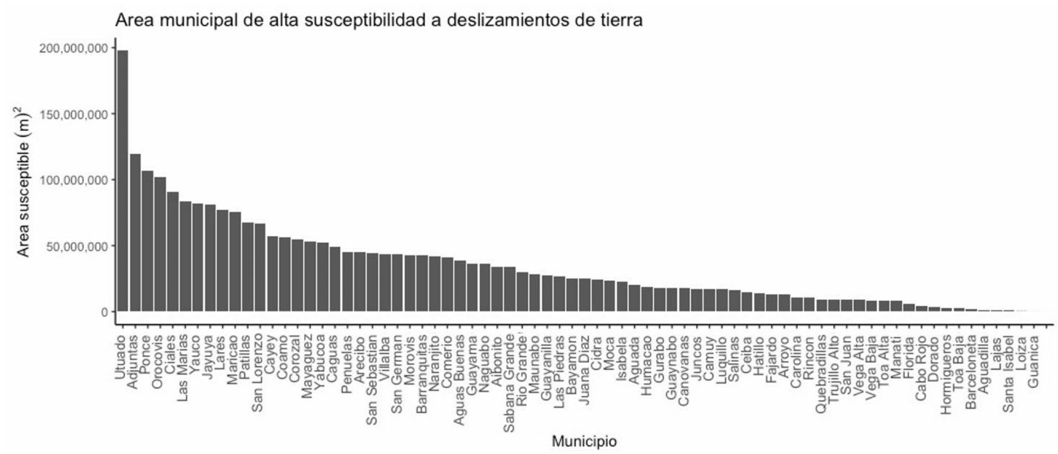


Figure 3-20. Graph of high landslide susceptibility by municipality.

The density of landslides that occurred during the passage of Hurricane Maria offers additional information that can be used by the responsible authorities to prevent the loss of life and property in the event of the occurrence of tropical cyclonic systems that generate large amounts of precipitation.

Studies conducted by UPRM determined that the high densities of post-María landslides were in areas that showed high soil moisture content based on satellite image analysis. The municipality with the highest landslide density was Utuado.

Exposure of Social Vulnerability to Landslide Risk.

To identify population exposure to risk, the High, Very High, and Extremely High categories from the Stephen Hughes & Schulz (2020) landslide susceptibility map and data provided by the American Community Survey, 2018 (5-year summary) were used as the basis. Demographic and socioeconomic variables such as total population, populations under 16 years old, over 65 years old, people with disabilities, females in charge of family units, head of household with income less than $10,000 annually were evaluated; These variables are used as they are understood to be indicators of social vulnerability.

According to **Table 3-36**, the total population in Puerto Rico exposed to landslide risk is approximately 486,920. The disabled population (107,235) and persons 65 years of age or older (88,269 persons) are the most prevalent population profile located in the risk zone. This is followed by the population 16 years of age or younger (84,653 inhabitants), female heads of household (34,783 inhabitants),

Table 3-36. Total Population in Puerto Rico Exposed to Landslides.

Area total con alta susceptibilidad a dezlizamiento de tierra a nivel Estatal para Puerto Rico	
Puerto Rico	2,600,260,849m²
Poblacion total con altas susceptibilidad a deslizamiento de tierra a Nivel Estatal para Puerto Rico	
Población Total	486,920
Población discapacitada	107,235
Población mayor de 65 años de edad	88,653
Población menor de 16 años de edad	84,787
Feminas de cargo del hogar	34,427

The municipalities with the highest total population exposed to landslides are Caguas, Utuado, Naranjito, Corozal, and San Lorenzo. (**Figure 3-21**).

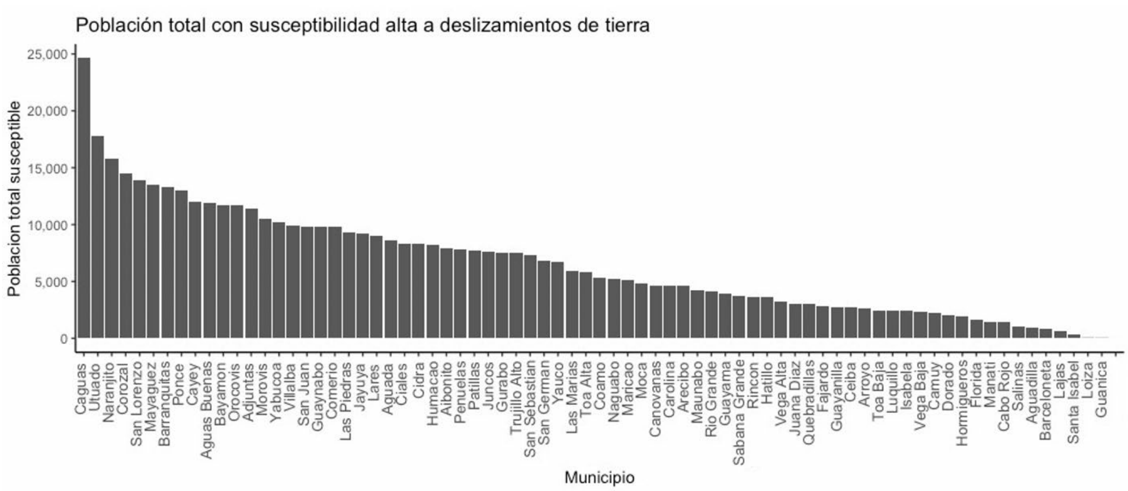


Figure 3-21. Municipalities with the highest population susceptible to landslides.

When the landslide risk is evaluated with the detailed demographic profile, it is identified that Caguas and Utuado are the municipalities with the highest number of people under 16 years of age and over 65 years of age located with increased susceptibility to landslides. These people should be a priority when it comes to risk mitigation since they depend on others to move from place to place. (see **Table 3-37**).

Table 3-37. Population susceptible to landslides (population 16 years old and younger; 65 years old and older)

Poblacion con suseptibilidad a deslizamientos:Variables Po-blaciónmenor de 16 años y mayor de 65 años				
Rango	Población menor de 16 años		Población mayor de 65 años	
1	Caguas	4371	Caguas	4195
2	Utuado	3232	Utuado	3524
3	Naranjito	2976	Naranjito	3459
4	Corozal	2679	Corozal	2701
5	Barranquitas	2655	Barranquitas	2457
6	Ponce	2477	Ponce	2340
7	San Lorenzo	2350	San Lorenzo	2256
8	Orocovis	2187	Orocovis	2174
9	Adjuntas	2112	Adjuntas	2138
10	Aguas buenas	2067	Aguas buenas	2117

Exposure of Physical Vulnerability and Critical Infrastructure to Landslide Risk.

According to **Table 3-38**, the critical infrastructure most susceptible to landslides is roads (tertiary, secondary,and proposed) and water and sanitary lines. Also, more than 200 schools are within the categories of high and moderate risk to landslide susceptibility. Power plants and power substations are not located in areas of increased vulnerability to landslide risk.

Table 3-38. Distribution of infrastructure according to the different levels of susceptibility to land-slides.

Distribución de infraestructura por los distintas niveles de suscepti-bilidad a deslizamientos		
Infraestructura	Nivel susceptibilidad	Cantidad
Plantas de energia	• Bajo • Moderado • Alto • Muy alto • Extremadamente alto	13 0 0 0 0
Subestaciones de ener-gia	• Bajo • Moderado • Alto • Muy alto • Extremadamente alto	325 13 1 0 0
Antenas celular	• Bajo • Moderado • Alto • Muy alto • Extremadamente alto	36 22 10 5 0
Escuelas	• Bajo • Moderado • Alto • Muy alto • Extremadamente alto	1467 185 20 5 0
Refugios	• Bajo • Moderado • Alto • Muy alto • Extremadamente alto	7991 800 215 51 2

3.6.3. Extreme Wind Hazards

According to 2016 PRSNHMP, hurricanes and tropical storms, which produce extreme wind gusts resulting from intense turbulence, are the most frequent event in Puerto Rico, causing extreme winds resulting in extensive damage and loss of life and property. A hurricane is a tropical cyclonic system with a sustained wind intensity greater than 74 miles per hour. It is important to note that tropical cyclone systems are categorized into 1) tropical depression, 2) tropical storm, and 3) hurricane. The tropical depression and tropical storms do not present extreme winds but could have sustained winds that could cause damage infrastructure. Within these three types of tropical cyclonic systems, hurricanes are (the most) dangerous because of their destructive potential, their ability to affect large areas, their capacity to form spontaneously, and their erratic movement.

The warming of the waters feeds the pressure gradient that can generate extreme winds. In the formation of tropical cyclones, it is the source of energy. It also influences the density of water masses, the variation of sea level height, and the dynamics of atmospheric systems.

A reconstruction of the last 5,000 years of intense cyclone activity in the western North Atlantic suggests that El Niño natural phenomena have strongly influenced hurricane variability during this time and that the previous 250 years have been relatively active in the context of these 5,000 years. According to the U.S. Global Change Research Program, the destructive potential of hurricanes and tropical storms in the Atlantic, as measured by the Energy Dissipation Index (which combines storm intensity, duration, and frequency), has increased. This increase is substantial since 1970, and is considerable since the 1950s and 1960s, and is associated with rising surface temperatures in the Atlantic. Likely, the annual number of tropical storms and hurricanes in the North Atlantic has increased over the last 100 years, during which time Atlantic surface temperatures have also increased¨. (PRCC, 2013).

The North Atlantic's maritime space is characterized because marine phenomena originate and follow diverse trajectories, such as Cape Verde-type hurricanes, which are those tropical cyclones in the Atlantic basin that develop into tropical storms quickly and quite close to these islands. Before reaching the Caribbean, they have become hurricanes. Typically, these occur in August and September. Generally, 0 to 5 hurricanes of this type of form per year, and the average is two (2) per season (Landsea, 1998). Likewise, the presence of strong shear winds, dry air, ocean temperatures below 81°F (27°C), and Saharan dust can limit the development of cyclones.

Knowing the aspects that cause hurricanes' formation with extreme winds, we become aware of the imminent threat they represent for Puerto Rico and the entire Caribbean. This analysis considered the definitions of extreme winds presented by the National Aeronautical and Space Administration (NASA) and the National Weather Service (NWS). According to this definition, extreme winds are considered to begin at category three hurricane. Hurricanes present a diversity of intensity categories and will be defined according to references from different local, state, and international entities that provide information on the risk description and management. For this reason, extreme winds will also be defined under general definitions of a hurricane and/or tropical cyclone formation. Among the hurricane definitions to be presented are NASA, NWS, FEMA, NOAA. IBC, PRCCC, among others.

FEMA's Hurricane Mitigation in Public Facilities Manual specifically defines hurricanes as "tropical cyclones, formed in the atmosphere over warm areas of the ocean, where the sustained wind speed reaches or exceeds 74 miles per hour and circles in a large spiral around the center of the eye. Hurricanes and other coastal storm events such as tropical storms and "Nor'easters" occur along the Atlantic, Gulf Coast, Puerto Rico, and the U.S. Virgin Islands. Hurricane intensities are measured using NOAA's Saffir-Simpson scale". (FEMA 2005, 16).

The Saffir-Simpson scale is a rating based on the sustained winds of a hurricane. The scale estimates potential property damage. Hurricanes that reach Category III and above are considered mega-hurricanes because of their significant potential for damage and life loss. Category 1 and 2 hurricanes are still dangerous and require preventive measures. (NOAA).

Table 3-39. Wind Rating according to Saffir-Simpson Scale

INFRASTRUCTURE IN FLOODPROOF AREA .01PCT: Schools		
Category	Sustained Winds	Type of Damage Due to Hurricane Winds
1	74-95 mph	Very dangerous winds that will produce some damage.
2	96-110 mph	Extremely dangerous winds will cause extensive damage.
3 (mega)	111-129 mph	Devastating damage will occur.
4 (mega)	130-156 mph	Catastrophic damage will occur.
5 (mega)	157 mph or more	Catastrophic damage will occur.

Source: NOAA

Usually, the hurricane's eye is observed in intense storms; this is when a cyclone reaches winds of category 3 or higher on the Saffir-Simpson scale. (Castro and López 2018). According to the Saffir-Simpson scale, hurricanes begin with maximum sustained winds of 74 mph. In contrast, according to the NWS definition of extreme winds, hurricanes form with maximum sustained winds of 115 mph or more. Therefore, by definition, extreme winds are category 3 hurricanes and above.

The NWS defines a tropical cyclone as a hurricane with a magnitude of 115 mph or greater or a category 3 hurricane or greater. The NWS has developed the Extreme Wind Warning (EWW) product to warn the public of the occurrence of winds associated with a hurricane landfall and the need to take shelter indoors in a safe structure during the event. The purpose of this product is to provide short alerts to the public and agencies moments before the rapid onset of destructive winds associated with the internal rain bands of major hurricanes. Warning alerts are strictly for events that pose a significant threat of casualties.

Table 3-40. Extreme Wind Warnings issued by the NWS.

Type of Newsletter	Time of Issue
Warning Bulletin	It reports on storms or hurricanes that have developed at sea and do not offer immediate danger to coastal areas.
Surveillance Bulletin	These bulletins are issued when winds may threaten coastal areas within 24 to 48 hours.
Newsletter	They are issued when coastal areas are in imminent danger of being buffeted by winds that will exceed 74 miles per hour within 24 hours.

Source: NWS

Extreme Wind Category according to the International Building Codes (IBC).
FEMA defines extreme winds as the wind that can exert significant force, or loads, on structures in their path from a construction perspective. Hurricane wind loads can cause a great deal of damage. Therefore, most mitigation actions to reduce the risk of damage to structures from hurricane winds involve reinforcing or strengthening the building.

According to FEMA, extreme winds can produce large amounts of debris that can become windborne and puncture the building envelope and openings, posing a threat to human life. Consequently, once a building is stuck, wind-driven rain can enter the building, causing water damage by water entering the building and affecting its contents. In turn, a broken window or glass door can also allow wind pressure to build up inside the house, causing structural damage.[22]

However, wind speed and location within the hurricane-prone region, exposure category is also an essential component in identifying a building's vulnerability to wind damage. Even as the terrain becomes more open, there is more potential for wind damage. Conversely, densely populated areas or potential wind-borne debris may be prone to other wind damage types. Therefore risk categories have

[22] Federal Emergency Management Agency. Wind Retrofit Guide for Residential Buildings.2010.

been created that are used to classify structures according to their importance and include considerations such as the risk to human life and the social need for the building or structure to function during and after an extreme event¨ (Stone, 2014).

In this extreme wind risk analysis, as seen on **Table 3-41**, only categories I and II were considered, which presents a scenario of how infrastructure is at risk when the arrival of extreme hurricane winds holds life within it. Category II includes those not defined as Risk Category I, III, or IV, including houses, apartment buildings, offices, and businesses. Category IV includes buildings designated as essential facilities intended to remain operational in extreme environmental loadings, such as power generation stations, police and fire stations, and other structures with critical functions. Categories I and III, are essential infrastructure that will be affected after the event, and although necessary, these structures are not life-protective at the time of high wind impact.

It is advisable to consider Infrastructure I and III for its vulnerability analysis, considering the need to protect agricultural areas, schools, and meeting spaces that can accommodate many people. It is recommended to add the variable of climate change as an additional threat to extreme winds. It has been documented to increase the intensity and frequency of formation and impact on all infrastructure types.

Table 3-41. Risk Category according to the International Building Code (IBC).

Category	Definition
Risk Category I	Buildings represent a low risk to human life in the event of a breakdown, such as agricultural facilities and storage buildings.
Risk Category II	These are those not defined as Risk Category I, III, or IV, including houses, apartment buildings, offices, and businesses.
Risk Category III	Buildings pose a substantial hazard to human life, such as schools and assembly buildings with an occupant load of over 300.
Risk Category IV	Buildings are designated as essential facilities intended to remain operational under extreme environmental loads, such as power generation stations, police and fire stations, and other structures with critical functions.

It has been observed how extreme winds have been a great threat to Puerto Rico. The country's infrastructure has been affected on multiple occasions and has proven to be not entirely resistant to face these types of winds. Hurricanes Hugo (1989), George (1998), and Maria (2017), present punctual examples of how part of the country's infrastructure has been impacted by the effect of extreme winds associated with these events.

However, the report Gone with the Wind: Estimating Hurricane and Climate Change Costs in the Caribbean establishes that there are not many documents that estimate the relationship between wind speed and the damage caused by tropical cyclones since most of these data have been done only for the U.S. mainland. [23]

Despite the lack of information and access data, it should be kept in mind that when planning, preventing, and mitigating, it is essential to consider extreme winds due to our geographic location and the threat this poses to life and infrastructure. The 2016 PRSNHMP presents the hurricane event as one of the most frequent and threatening hazards in Puerto Rico. Damage to buildings and infrastructure can be caused either by high winds or by windblown debris acting as wind-driven projectiles. In Puerto Rico, the hurricane season lasts six months,from June to November. However, hurricanes can develop outside the season since they are spontaneously generated phenomena, and their movement and development are erratic.

It is essential to mention and highlight some of the hurricanes that caused the most significant damage to infrastructure due to extreme winds between 1928 and 2020. These are:

- Hurricane San Felipe (1928): Category four (4) hurricane with sustained winds of 231 km/hr (144 mph) according to NOAA. It caused significant damage to farms and property, 312 people dead, 83,000 people without shelter, and caused losses of US$50 million.
- Hurricane Hugo (1989): This system approached USVI on September 17, 1989, as a category four (4) hurricane, with maximum sustained winds of 140 mph (225 km/hr) and a minimum sea-level pressure of 934 Mb (NOAA, 1990). However, when it began to be felt in Puerto Rico (September 18), the Naval Air Station at Roosevelt Roads, PR, reported sustained winds of 104 mph with gusts of up to 120 mph highest winds ever recorded in the Caribbean. Hurricane Hugo caused enormous damage to development and infrastructure in eastern Puerto Rico. More than 80 percent of the wooden structures were destroyed in Culebra and Vieques (FEMA, 1989). Thirty thousand people were left homeless, and property damage exceeded $1 billion. (USGS)
- Hurricane Georges (1998): The most destructive hurricane in recent times (and the most like Hurricane Maria) is Hurricane Georges. A 1999 FEMA damage assessment estimate was published, detailing a total damage estimate of $5.7 billion. More than $4 billion of the hurricane's damage was inflicted on homes and other structures; damage to the electrical grid was estimated at more than $350 million. The communications sector suffered damage estimated at $22 million. (FEMA)

[23] Acevedo Mejía, Sebastián.Gone with the Wind: Estimating Hurricane and Climate Change Costs in the Caribbean. International Monetary Fund. 2016.

- Hurricane Maria (2017). It presented a diverse distribution of extreme winds across the island. This is because the distribution of winds across the hurricane structure is not homogeneous that, according to the National Hurricane Center Tropical Cyclone Report the system swept through Puerto Rico as a high- level Category 4. Hurricane Maria's maximum wind intensity was estimated at 173 miles per hour. Besides, the increased wind intensity of 74 miles per hour for 24 hours on September 18 makes it the sixth highest intensity hurricane on record for the Atlantic Basin (NWS).

The occurrence of atmospheric events, mostly hurricanes, makes visible how vulnerable Puerto Rico is to extreme winds. Therefore, there must be a detailed plan with experts on the subject to face strong winds in the best possible way, considering the precariousness of the infrastructure and safeguarding the people's lives. Also, the pattern observed is an emergency call to evaluate and attend to the major infrastructures of the island that have been weakening for decades, and most of the population has not received the necessary government assistance. This could be witnessed after Hurricane Maria's passage that much of the infrastructure is still unattended three years later, and a large percentage of the population lives in a precarious situation due to lack of attention from the government.

CDBG MIT Action Plan incorporated the Extended Best Track (EBT) data from the National Hurricane Center for all Atlantic tropical cyclones. The CDBG-MIT used the HURDAT system which contains information on each storm including estimates of latitude, longitude, one (1) minute maximum sustained winds at the surface, minimum sea level pressure and information indicating whether the system was purely tropical, subtropical, or extra tropical, at six (6) hour intervals. However, the system lacks information on storm structure. By supplementing HURDAT with additional parameters determined by the National Hurricane Center, the "extended" best track file was created. These additional parameters include Maximum radial magnitude of thirty-four (34), fifty (50) and sixty-four (64) knot winds in four (4) quadrants, the radius of maximum winds, Eye diameter (if available), pressure and radius of the outer closed isobar.

Among the results that CDBG-MIT highlights are that the eastern region of Puerto Rico has experienced hurricane speed winds more frequently than the rest of the island. While the island of Mona has experienced the least number of events -eight (8) occasions- of hurricane intensity winds. The municipalities of Fajardo and Luquillo are completely within the highest hurricane frequency category, from nineteen (19) to twenty-one (21), while the islands located east of Fajardo have received hurricane winds on twenty-one (21) occasions during the last thirty (30) years. Most of the rest of the central and northwestern area of Puerto Rico has had between sixteen (16) and eighteen (18) hurricane wind events during the last thirty (30) years. hurricane wind events during this same independent period, while the southeastern areas of the island have been impacted between thirteen (13) and fifteen (15) times.

Vulnerability Assessment

A series of physical variables (topography, roughness, vegetation, and infrastructure) that influence the extreme wind speed at the time of quantification were considered for the extreme wind model. This extreme wind design model is based on categories II and IV. Category II includes houses, apartment buildings, offices and businesses as shown in **Table 3.** Category IV includes buildings that are designated as essential facilities intended to remain operational under extreme environmental loadings, such as power generation stations, police and fire stations, and other structures with critical functions. These results took into consideration topography, vegetation, roughness, and building code per the IBC

The ten (10) municipalities most exposed to extreme winds based on category II according to the IBC are Arroyo; Maunabo; Patillas; Yabucoa; Ceiba; Juana Díaz; Naguabo; Villalba; Cayey and Ciales, according to **Table 3-42.** The municipalities of Arroyo, Maunabo, Yabucoa, and Patillas are the most exposed to extreme winds with a speed of 180 miles per hour. They are followed by Ceiba, Juana Diaz, Naguabo, and Villalba with extreme winds of 170 miles per hour. While the other municipalities of Cayey and Ciales, presented a maximum speed of 160 miles per hour.

Table 3-42. Municipalities most vulnerable to extreme winds by Category II

Municipality	Winds Max.	Max. Cat. Hurricane
Arroyo	180	5
Maunabo	180	5
Patillas	180	5
Yabucoa	180	5
Ceiba	170	5
Juana Diaz	170	5
Naguabo	170	5
Villalba	170	5
Cayey	160	5
Ciales	160	5

The municipalities most exposed to extreme winds according to the extreme wind model in category IV are: Maunabo; Patillas; Yabucoa; Arroyo; Ceiba; Naguabo; Juana Díaz; Guayama; Jayuya and Río Grande **(Table 3-43).**

Maunabo, Patillas, and Yabucoa are the three municipalities most exposed to extreme winds of 320 miles per hour. They are followed by Arroyo, Ceiba, and Naguabo with extreme winds of 310 miles per hour. The case of Juana Diaz presented an exposure of 100 miles per hour. The other three municipalities (Guayama, Jayuya, and Río Grande) had a maximum speed of 290 miles per hour.

Table 3-43. Municipalities most vulnerable to extreme winds according to Category IV.

Municipality	Max. winds Cat. IV	Max. Hurricane Cat.
Maunabo	320	5
Patillas	320	5
Yabucoa	320	5
Arroyo	310	5
Ceiba	310	5
Naguabo	310	5
Juana Diaz	290	5
Guayama	290	5
Jayuya	290	5
Rio Grande	290	5

Social Vulnerability Analysis

Exposure to hazards and environmental risks from a disaster is delineated by crucial social structures such as class, genetic diversity and ethnicity, age and physical ability, sex, and gender (Hearn, 2000). In this analysis, demographic and socioeconomic variables were selected: total population; the number of persons aged 65 years or older, persons aged 16 years or younger, persons with annual income of $10,000 or less, persons with disabilities (women and men), and the number of female heads of households are highly vulnerable to risk exposure. The demographic data were obtained from the 2018 American Community Survey with a five-years estimate, which is not entirely representative of our current socio-environmental, political, and economic events. These events have impacted the Island and the population in different geographic areas. It should be noted that the ten municipalities with the most vulnerable population exposed to extreme winds have been selected.

Total population exposed to risk.

The municipality with the largest population exposed and vulnerable to extreme winds (according to this model in category II and IV) is San Juan, with a total of 344,606 inhabitants. Then, Bayamón (182,955), Carolina (157,453), Ponce (143926), Caguas (131,363), Guaynabo (88,663), Arecibo (87,242), Toa Baja (79,726), Mayagüez (77,255) and Toa Alta (73,405) continue to decrease their exposure. (Table 3-44 and Table 3-45).

Table 3-44 . Number of population exposed to risk according to category II.

Municipality	Estimated Total Population	Max. winds Cat. II
San Juan	344,606	220
Bayamón	182,955	220
Carolina	157,453	240
Ponce	143,926	260
Caguas	131,363	240
Guaynabo	88,663	230
Arecibo	87,242	220
Toa Baja	79,726	200
Mayagüez	77,255	220
Toa Alta	73,405	210

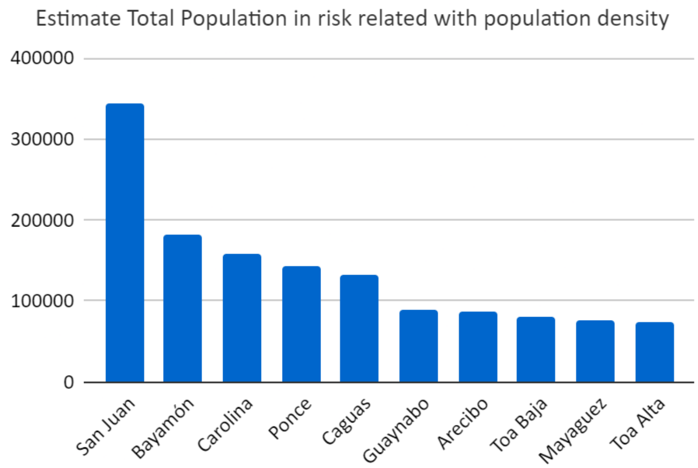


Figure 3-21. Municipalities with the highest population susceptible to land-slides.

Table 3-45. Number of the population exposed to risk according to category IV

Municipality	Estimated Total Population	Max. winds Cat. II
San Juan	344,606	220
Bayamón	182,955	220
Carolina	157,453	240
Ponce	143,926	260
Caguas	131,363	240
Guaynabo	88,663	230
Arecibo	87,242	220
Toa Baja	79,726	200
Mayagüez	77,255	220
Toa Alta	73,405	210

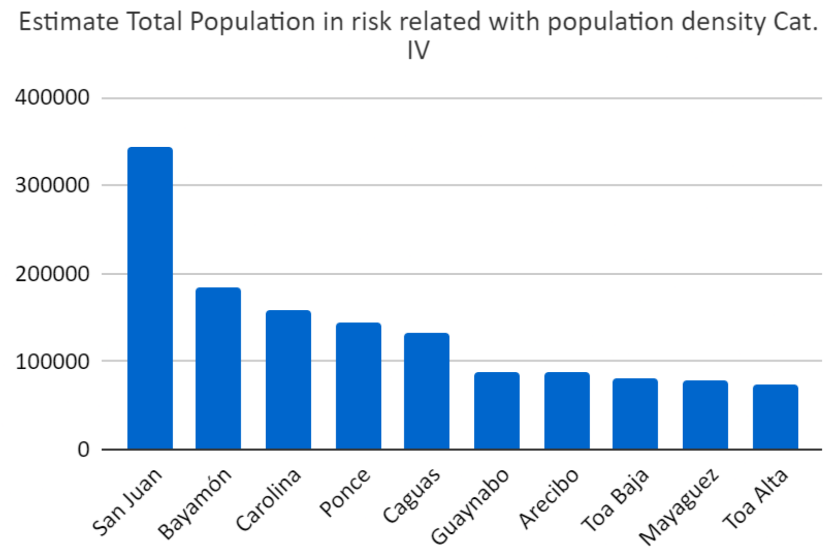


Figure 3-22. Total Estimated Population at Risk according to population density Cat II.

This demonstrates a risk of vulnerability for the population since a high volume of people could be harmed. It is recommended to start a population education plan, make the problem visible, consider when building or rebuilding the type of structure, and create building codes adapted to a new reality after hurricanes Irma and Maria.

Number of people over 65 years of age exposed to risk.
The municipality with the greatest number of people 65 years of age or older exposed and vulnerable to the risk of extreme winds (according to category II and IV) is San Juan, with a total of 72,541 older people. D is decreasing in exposure are Bayamón (37,188), Carolina (32,826), Ponce (28,762), Caguas (24,767), Guaynabo (18,190),Arecibo (17,765), Mayagüez (17,339), Toa Baja (14,319) and Trujillo Alto (11,832), according to **Tables 3-46 and 3-47.**

The data shows that there is a large aging population in urban areas exposed to this risk. It is considering that this is our most vulnerable population and mostly alone, living in care centers or being cared for by another elderly person. Most live-in coastal municipalities, which could increase their risk to other events. According to the Red State Data Center of the U.S. Census Bureau in Puerto Rico and the Puerto Rico Institute of Statistics, about 20% of the population in Puerto Rico is over 65 years of age.

Table 3-46. Number of people over 65 years of age exposed to risk. according to Cat. II.

Municipality	65 years of age or older	Max. winds Cat. II
San Juan	72,541	220
Bayamón	37,188	220
Carolina	32,826	240
Ponce	28,762	260
Caguas	24,767	240
Guaynabo	18,190	230
Arecibo	17,765	220
Mayagüez	17,339	200
Toa baja	14,319	220
Trujillo alto	11,832	230

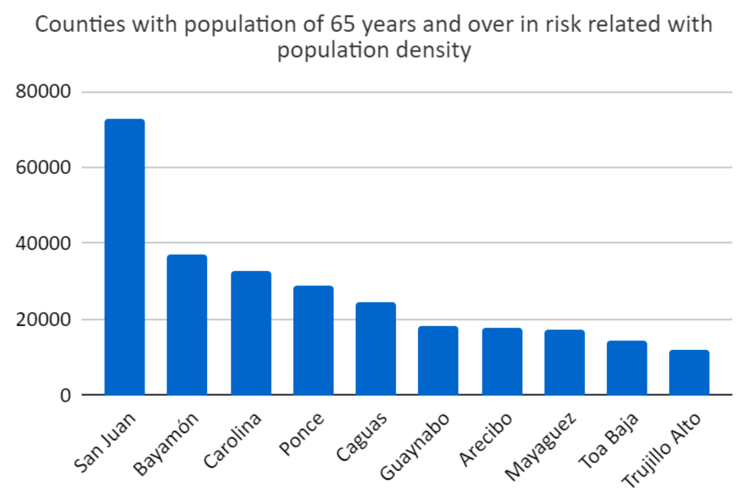


Figure 3-23. Municipalities with population aged 65 and over related to population density.

Table 3-47. Number of people over 65 years of age exposed to risk according to Cat. IV.

Municipality	65 years of age or older	Max. winds Cat. IV
San Juan	72,541	240
Bayamón	37,188	240
Carolina	32,826	
Ponce	28,762	
Caguas	24,767	
Guaynabo	18,190	
Arecibo	17,765	240
Mayagüez	17,339	240
Toa baja	14,319	220
Trujillo alto	11,832	230

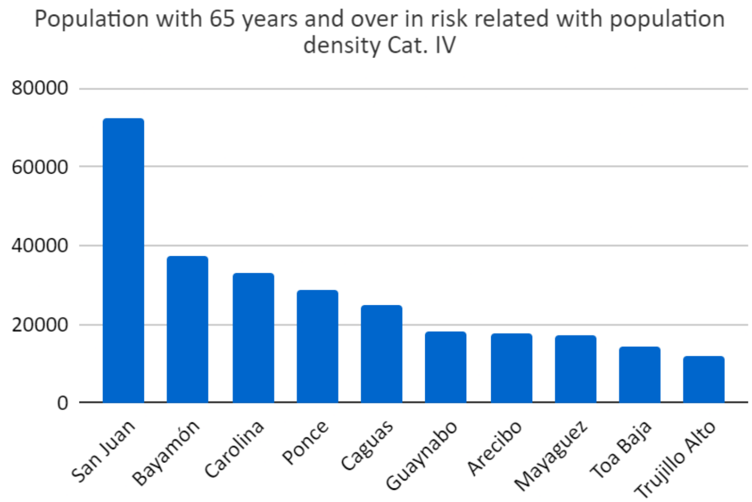


Figure 3-24. Population 65 years and older at risk related to population density Cat.IV.

Number of people under the age of 16 exposed to risk

The municipality with the highest number of people under 16 years of age exposed and vulnerable to the risk of extreme winds (according to category II and IV) is San Juan, with a total of 55,907 minors. Bayamón (29,773), Carolina (26,422), Ponce (26,056), Caguas (22,836), Arecibo (14,530), Toa Baja (14,112), Guaynabo (13,528) and Trujillo Alto (12,084) continue to decrease their exposure. (Table 3-48 and 3-49).

Like the aging population, children under the age of 16 are also highly vulnerable because they are dependent on a family member or guardian, which is why the risk increases for them near coastal areas.

Table 3-48. Number of people under 16 years of age exposed to risk according to Cat. II.

Municipality	16 years old or younger	Max. winds Cat. II
San Juan	55,907	220
Bayamón	29,773	220
Carolina	26,422	240
Ponce	26,056	260
Caguas	22,836	240
Arecibo	14,530	220
Toa Baja	14,112	230
Guaynabo	13,642	240
Toa baja	13,528	200
Trujillo alto	12,084	230

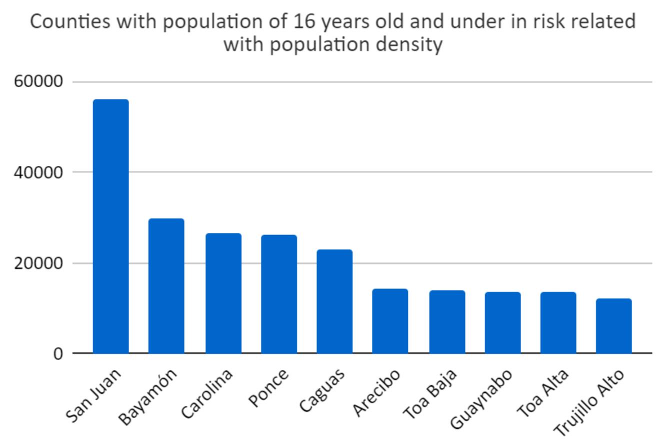


Figure 3-25. Municipalities with population 16 years of age or younger under density-related risk. Population.

Table 3-49. Number of people under 16 years of age exposed to risk according to Cat. IV.

Municipality	16 years old or younger	Max. winds Cat. IV
San Juan	55,907	240
Bayamón	29,773	240
Carolina	26,422	250
Ponce	26,056	280
Caguas	22,836	270
Arecibo	14,530	240
Toa Baja	14,112	220
Guaynabo	13,642	250
Toa baja	13,528	230
Trujillo alto	12,084	250

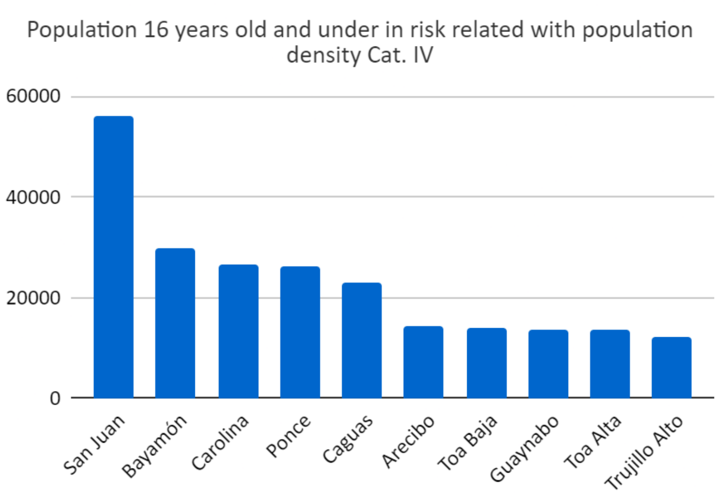


Figure 3-26. Population aged 16 years or younger at risk related to population density.

Number of people with an annual income of less than $10,000

The U.S. Census Bureau released in 2019 the most recent data from the Puerto Rico Community Survey known as the Puerto Rico Community Survey. These statistics refer to information collected for five (5) years, from 2014 to 2018. The publication provides data on demographic, social, economic, and housing characteristics for Puerto Rico and municipalities and specific geographic levels such as neighborhoods, census tracts, and block groups. The Puerto Rico Institute of Statistics (Institute) presents different results of interest where during the period 2014-2018, among the economic characteristics of Puerto Rico and its municipalities, it was found that:

- 36 of the 78 municipalities had 50% or more of their population living in poverty.
- Of those 36 municipalities, in 6 of them, the poverty level reached between 60% and 64%, Maricao, Guánica, Adjuntas, Lajas, Jayuya, and Comerío. In other words, 6 out of every 10 people in the municipalities mentioned above are in poverty.
- In Puerto Rico, 44.5% of the population and 40.9% of families live in poverty.
- On the other hand, median household income decreased in 50 municipalities.
- In Puerto Rico, the median household income decreased significantly by 4.9%, translating to about $1,047 annually.
-

Against this backdrop, it can be established that, in percentage terms, the level of poverty continues to be high throughout Puerto Rico, as can be seen in Figure 3-27.

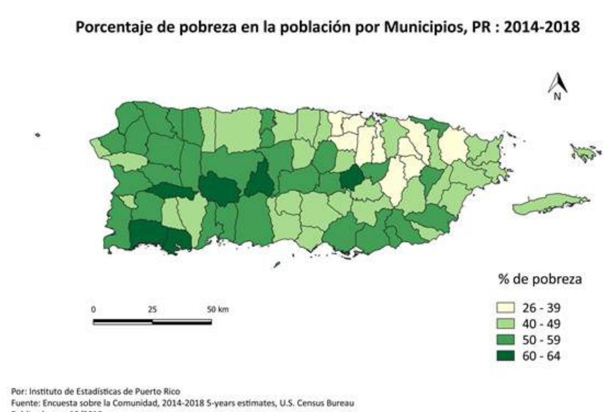


Figure 3-27. Map of Percentage of Poverty by Municipality in Puerto Rico

The municipality with the highest number of people with an annual income of less than $10,000 exposed and vulnerable to the risk of extreme winds (according to category II and IV) is San Juan with a total population of 44,198. Then decreasing in exposure are Ponce (17,290), Bayamón (14,689), Mayagüez (11,833), Carolina (10,958), Caguas (10,772), Arecibo (10,185), Aguadilla (6,966), Toa Baja (6,179) and Cabo Rojo (5,250), (**Table 3-50 and 3-51**).

This shows that high levels of the population with low-income levels in urban and coastal areas are exposed tohigher risk and are highly vulnerable to recovery after the event. It is considering that with an income of less than $10,000 per year, this population may not have access to safe housing and less access to risk preparedness.

Table 3-50. Population with an annual income less than $10,000 at risk according to category II.

Municipality	Annual household income less than $10,000	Max. winds Cat. II
San Juan	41,198	220
Bayamón	17,290	260
Carolina	14,689	220
Ponce	11,833	220
Caguas	10,958	240
Arecibo	10,772	240
Toa Baja	10,185	220
Guaynabo	6,966	180
Toa baja	6,179	200
Cabo Rojo	5,250	240

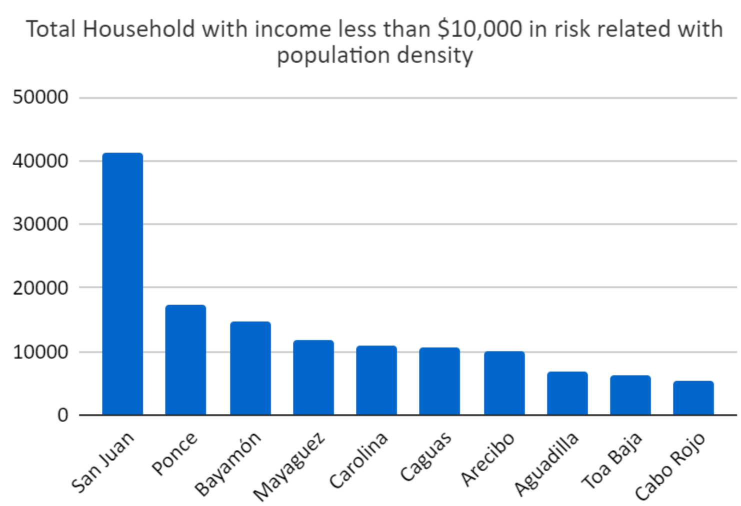


Figure 3-28. Annual household income less than$10,000 under risk related to population Density.

Table 3-51. Population with an annual income of less than $10,000 exposed to risk according to category IV

Municipality	Annual household income less than $10,000	MAX_Contour IV
San Juan	41,198	240
Ponce	17,290	280
Bayamón	14,689	240
Mayagüez	11,833	240
Carolina	10,958	270
Caguas	10,772	270
Arecibo	10,185	240
Aguadilla	6,966	210
Toa baja	6,179	220
Cabo Rojo	5,250	270

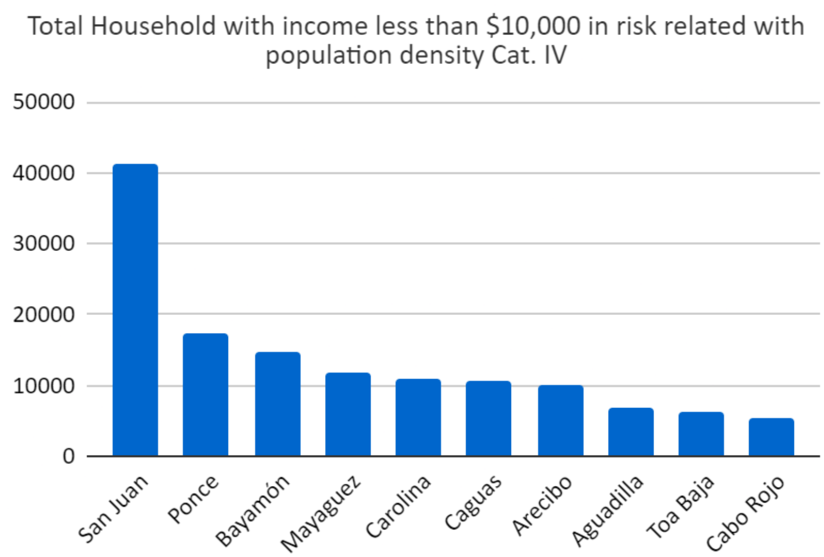


Figure 3-29. Total Household Income less than $10,000 under density-related risk population Cat. IV.

Population with disabilities.

The total number of people with disabilities exposed to the risk of extreme winds (according to category II and IV) is found in San Juan, with a total population of 66,338. Then Bayamón (47,649), Carolina (35,455), Caguas (31,075), Ponce (24,756), Mayagüez (20,843), Guaynabo (20,151), Arecibo (17,640), Toa Baja (16,219) and Cayey (14,277) continue to decrease their exposure. See **Table 3-52.**

Table 3-52. Population with disabilities exposed to risk according to Cat. II.

Municipality	Annual household income less than $10,000	Winds Max. Cat. II
San Juan	66,338	220
Bayamón	47,640	220
Carolina	35,455	240
Caguas	31,075	240
Ponce	24,756	260
Mayagüez	20,843	220
Guaynabo	20,151	230
Arecibo	17,640	220
Toa baja	16,219	
Cayey	14,277	260

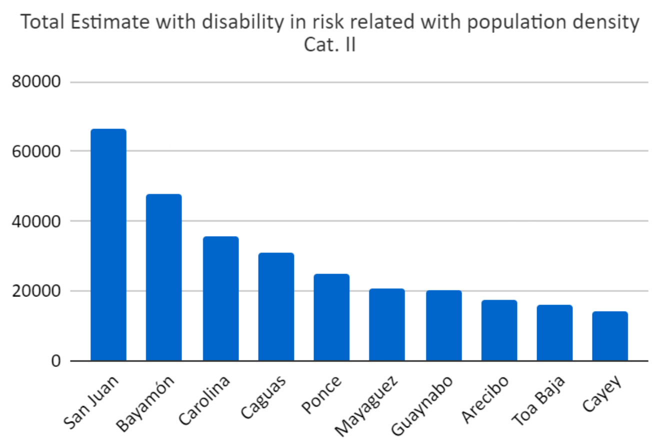


Figure 3-30. Estimated total number of people with disabilities at risk related to population density.

Table 3-53. Population with disabilities exposed to risk according to Cat. IV

Municipality	Estimated total number of people with disabilities	Winds Max. Cat. IV
San Juan	66,338	240
Bayamón	47,640	240
Carolina	35,455	250
Caguas	31,075	270
Ponce	24,756	280
Mayagüez	20,843	240
Guaynabo	20,151	250
Arecibo	17,640	240
Toa baja	16,219	220
Cayey	14,277	280

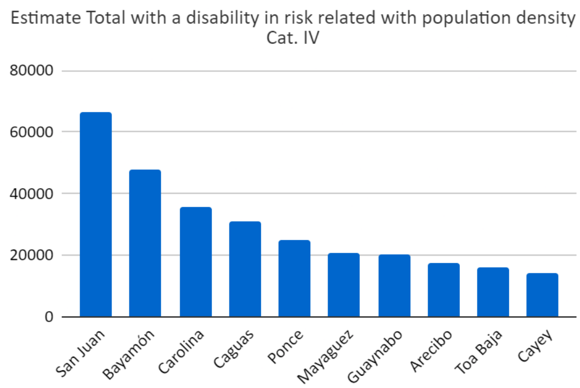


Figure 3-31. Estimated Population with Disabilities in Risk under Population Density, Cat. IV

The total number of women with disabilities exposed to the risk of extreme winds (according to category II and IV) is found in the town of San Juan with a total of 37,476 women. Then, decreasing in exposure are the towns of Bayamón (26,450), Carolina (19,765), Caguas (16,561), Ponce (13,302), Mayagüez (11,193), Guaynabo (11,074), Arecibo (9,294), Toa Baja (8,762) and Cayey (7,646). See **Figures 3-31 and 3-32.**

The total number of men with disabilities exposed to the risk of extreme winds (according to category II and IV) is found in San Juan, with a total of 28,862. Then, decreasing in exposure are the towns of Bayamón (21,190), Carolina (15,690), Caguas (14,514), Ponce (11,454), Mayagüez (9,650), Guaynabo (9,077), Arecibo (8,346), Toa Baja (7,457) and Cayey (6,631). See **Tables 3-54 and 3-55.**

This shows that the number of disabled women in these municipalities is higher than the number of disabled men exposed to the risk of extreme winds. However, the total number of disabled people exposed to this risk is high. This could represent people with mobility challenges who may find it more challenging to leave vulnerable areas.

Table 3-54. Total number of women with disabilities exposed to risk according to Category II.

Municipality	Estimate of Women with Disabilities	Max. winds Cat. II
San Juan	37,476	220
Bayamón	26,450	220
Carolina	19,765	240
Caguas	16,561	240
Ponce	13,302	260
Mayagüez	11,193	220
Guaynabo	11,074	230
Arecibo	9,294	220
Toa baja	8,762	200
Cayey	7,646	260

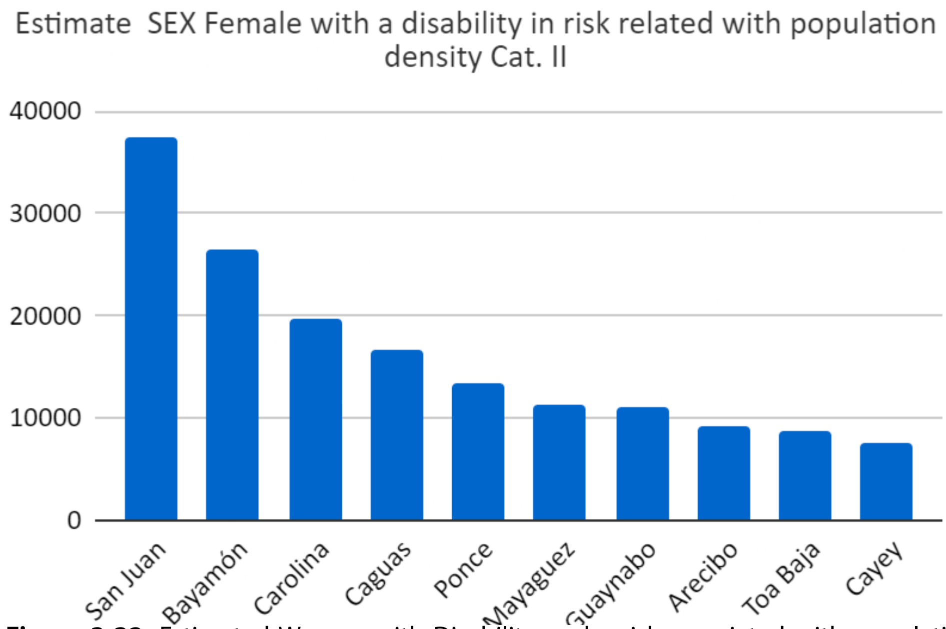


Figure 3-32. Estimated Women with Disability under risk associated with population density. Cat. II.

Table 3-55. Total number of females with disabilities exposed to risk according to category IV.

Municipality	Estimate of Women with Disabil-ities	Max. winds Cat. IV
San Juan	37,476	240
Bayamón	26,450	240
Carolina	19,765	250
Caguas	16,561	270
Ponce	13,302	280
Mayagüez	11,193	240
Guaynabo	11,074	250
Arecibo	9,294	240
Toa baja	8,762	220
Cayey	7,646	280

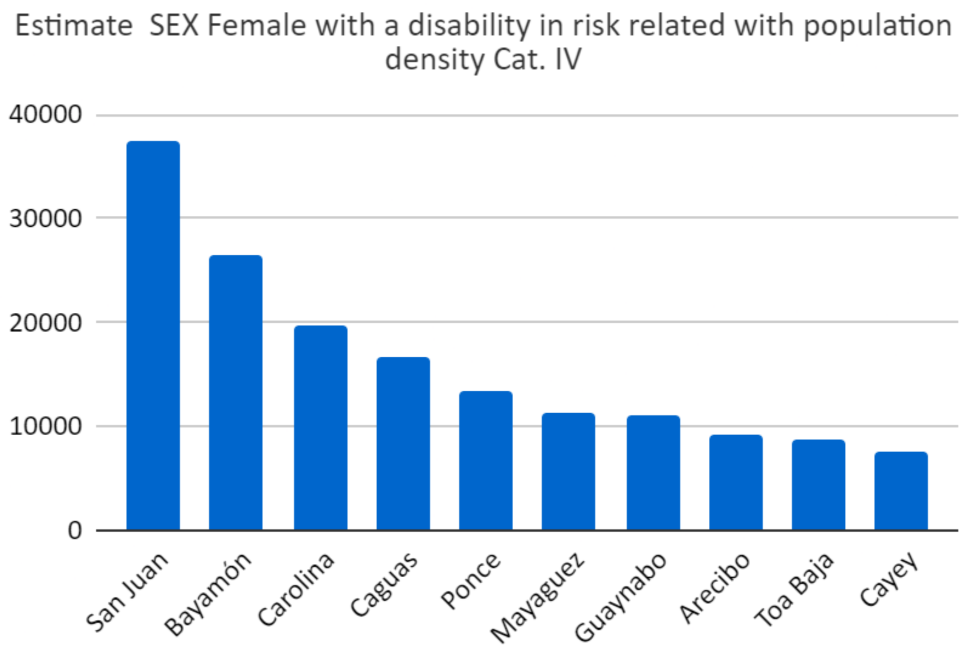


Figure 3-33. Estimated Women with Disabilities at Risk by Population Density Cat. IV.

Table 3-56. Total number of men with disabilities exposed to risk according to Category II.

Municipality	Estimated Men with Disabilities	Max. winds Cat. II
San Juan	37,476	220
Bayamón	26,450	220
Carolina	19,765	240
Caguas	16,561	240
Ponce	13,302	260
Mayagüez	11,193	220
Guaynabo	11,074	230
Arecibo	9,294	220
Toa baja	8,762	200
Cayey	7,646	260

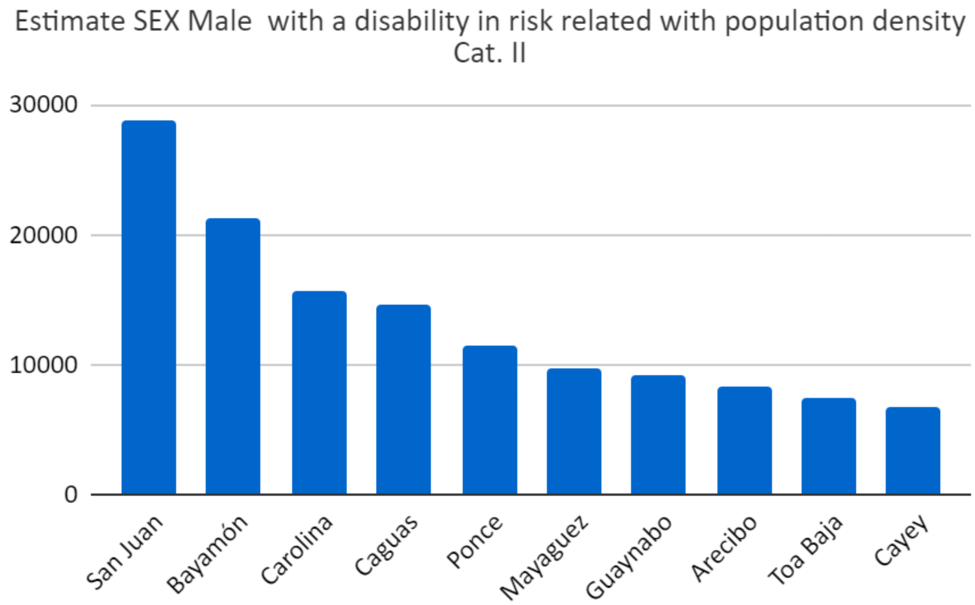


Figure 3-34. Estimated Men with disabilities at risk related to population density Cat. II

Table 3-57. Total number of men with disabilities exposed to risk according to category IV.

Municipality	Estimated Men with Disabilities	Max. winds Cat. IV
San Juan	28,862	240
Bayamón	21,190	240
Carolina	15,690	250
Caguas	14,514	270
Ponce	11,454	280
Mayagüez	9,650	240
Guaynabo	9,077	250
Arecibo	8,346	240
Toa baja	7,457	220
Cayey	6,631	280

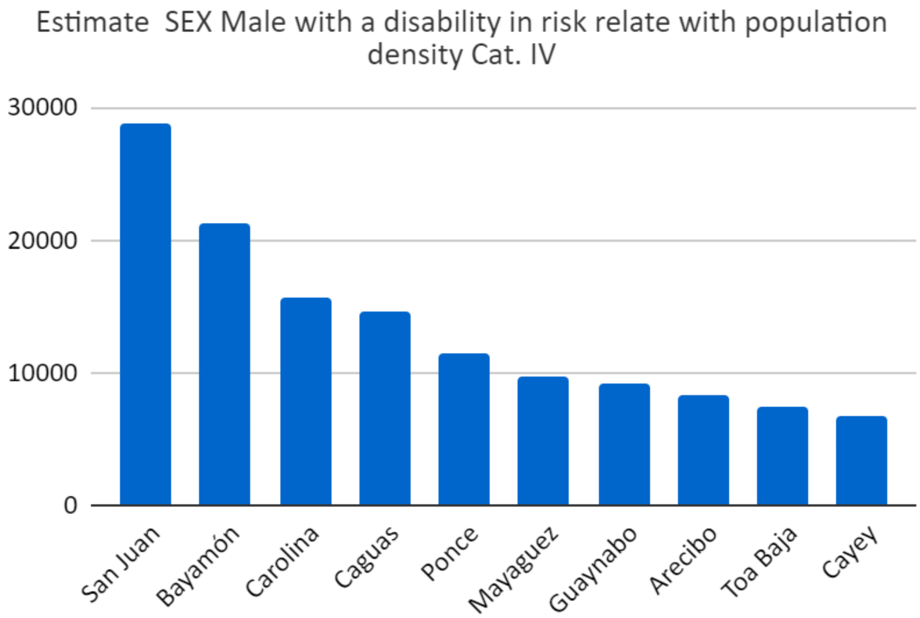


Figure 3-35. Estimated Men with disabilities under risk of population density Cat. IV.

Number of women in charge of households

The number of women in charge of households exposed to the risk of extreme winds (according to category II and IV) is found in San Juan with a total of 35,049. Bayamón (17,452), Carolina (16,581), Ponce (13,916), Caguas (12,383), Arecibo (7,707), Mayagüez (6,857), Toa Baja (6,857) Guaynabo (6,209) and Trujillo Alto (6,011) continue to decrease their exposure. See **Tables 3-58 and 3-59.**

Table 3-58. Number of female heads of households exposed to risk according to category II.

Municipality	Total Female Heads of House-hold without a partner	MAX_Contour II
San Juan	35,049	220
Bayamón	17,452	220
Carolina	16,581	240
Ponce	13,916	260
Caguas	12,383	240
Arecibo	7,707	220
Mayagüez	6,857	220
Toa Baja	6,571	200
Guaynabo	6,209	230
Trujillo Alto	6,011	230

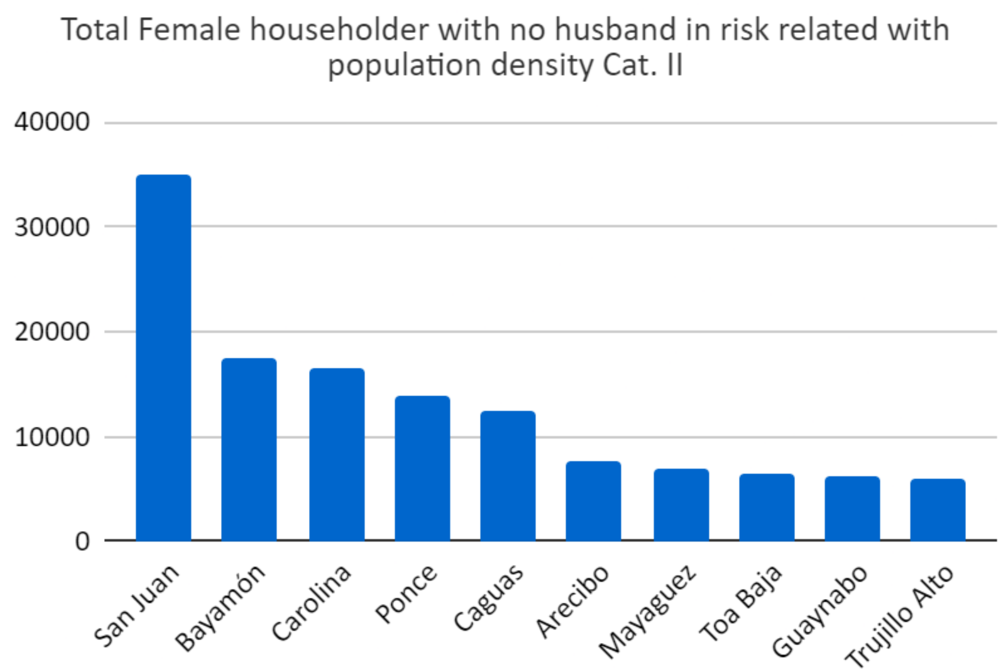


Figure 3-36. Total Female Householders without husband in risk related to population density.

Table 3-59. Number of female heads of household exposed to risk according to category IV.

Municipality	Total Female Heads of Household without a partner	Max. winds Cat. IV
San Juan	35,049	240
Bayamón	17,452	240
Carolina	16,581	250
Ponce	13,916	280
Caguas	12,383	270
Arecibo	7,707	240
Mayagüez	6,857	240
Toa Baja	6,571	220
Guaynabo	6,209	250
Trujillo Alto	6,011	250

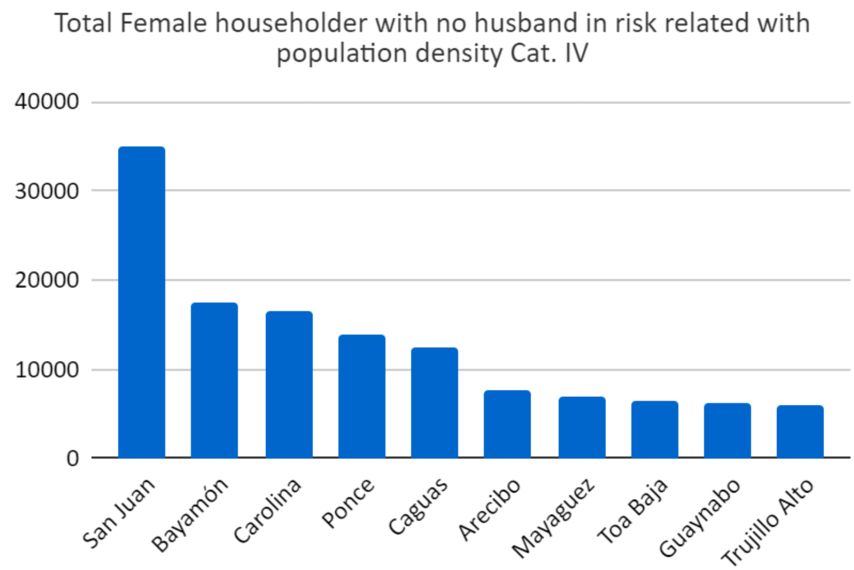


Figure 3-37. Total female heads of household without a partner under risk related to population density Cat. IV.

Focusing on women's vulnerability, we can affirm that they are the sector of the population most at risk in the event of a disaster. Studies demonstrate that after analyzing natural disasters in 141 countries, it was detected that women and girls are 14 times more likely to die than men due to gender differences and existing inequalities related to their economic and social rights. When a disaster occurs, women fear being victims of domestic and sexual violence due to several factors among them: having to stay with their aggressors at home for consecutive days or even hours (UN-HABITAT, 2019).

To understand the risks, it is essential to incorporate gender considerations to analyze vulnerabilities and community capacities. In most cases, disasters place an additional burden on women and girls, as they are responsible for unpaid work (providing care, water, and food for households, among others) while at the same time exacerbating conditions of poverty, access to education, and participation in political and domestic decision-making. Economic and social inequalities mean that women have fewer assets and means, which increases their vulnerability to hazard.

In the case of Puerto Rico, "female heads of household constitute 8% of the population and may have fewer resources to recover from a disaster than families with more than one provider" Also, it has been highlighted that typically, women and girls are disproportionately affected by emergencies. That is why it was observed that violence against women increased after Hurricane Maria, and, there was an increase in the number of femicides (Vigaud-Walsh, 2018). This reflects a significant concern in addressing these problems, and the action should be taken with urgencies. Emergency plans lack a gender perspective that addresses all the women's threats as part of the most vulnerable population.

Critical Infrastructure Assessment.

For the analysis of this data, the maximum and minimum speed for each municipality was obtained and, in turn, the total amount of infrastructure for each municipality closest to the risk of extreme winds (isolines). It is essential to keep in mind that all wind speeds (mph) are equivalent to severe winds, so the analysis focused on the total amount of infrastructure for each municipality to highlight vulnerability. Following data will show the specific maximum speed for each municipality, which increases its total vulnerability.

According to the PRCC, metropolitan municipalities, such as San Juan and Carolina, are where activities and services are concentrated: Puerto Rico's principal seaport and airport; the most critical health center in Puerto Rico and the Caribbean (Centro Médico); and the main universities. Government services are also highly concentrated in San Juan, the coastal zone of the San Juan metropolitan area, as well as other coastal areas are where most of the hotels, essential infrastructure, and power plants (some power plants are less than 160 feet from the waterline and less than six feet above sea level).

Structures that are considered at risk due to existing hazards are residential homes, power generation plants, sewage systems, cemeteries, recreational areas, community centers/libraries, government buildings and facilities, schools, and hospitals. The PRCC, through discussions and the use of municipal hazard mitigation plans that, according to historically observed climate trends, Puerto Rico is currently at risk due to the following practices:

- Continued infrastructure development in high-risk areas or areas of poor drainage.
- Increase in land use change and area of impervious surfaces.
- Inadequate use of shoreline stabilization structures in certain areas.
- Poor maintenance of existing coastal stabilization structures.
- Deficient maintenance and dredging of rivers, canals, and reservoirs.
- Inadequate capacity and maintenance of stormwater management systems.
- Deficient soil management practices in terrestrial and coastal watersheds.
- Inadequate construction practices that do not follow established codes.
- Elimination of dunes, reefs, mangroves, and other natural protective features¨ (PRCC, 2013)

Number of substations of the Puerto Rico ElectricPowerAuthority (PREPA)

The largest number of PREPA substations exposed to the risk of extreme winds (according to category IV) is in San Juan with a total of 64 substations. Then, decreasing the number of substations, are Ponce (64), Bayamón (16), Carolina (12), Mayagüez (12) and Aguadilla (11), Caguas (11), Guaynabo (10), Arecibo (9) and Cabo Rojo (6) **(Table 3-60).**

Table 3-60. Number of PREPA substations exposed to risk according to category IV.

Municipality	Frequency	Max. winds Cat. IV	Winds Min. Cat. IV
San Juan	35,049	190	180
Ponce	17,452	190	180
Bayamón	16,581	180	180
Carolina	13,916	180	180
Mayagüez	12,383	240	170
Aguadilla	7,707	180	170
Caguas	6,857	180	180
Guaynabo	6,571	180	180
Arecibo	6,209	180	170
Cabo Rojo	6,011	190	170

Number of plants of the Puerto Rico ElectricPowerAuthority (PREPA) Winds Min. Cat. IV

Puerto Rico's relatively high per capita energy and fuel consumption, both in electricity and transportation (one car for every 1.3 Puerto Ricans) - contributes to the causes of global climate change. (CPRCC, 2013). So, in times of electricity system failure, the population relies on alternative power generation plants, most of which use fossil fuels.

The number of PREPA's power plants exposed to the risk of extreme winds (according to category IV) is found in Guayama and Peñuelas with a total of 2 plants in each municipality. Arecibo, Ceiba, Guayanilla, Mayagüez, Salinas, San Juan, Toa Baja and Villalba are next with 1 plant per municipality. See **Table 3-61.**

Table 3-61. Number of PREPA plants exposed to risk according to category IV.

Municipality	Frequency	Max. winds Cat. IV	Winds Min. Cat. IV
Guayama	2	190	190
Peñuelas	2	180	
Arecibo	1	170	170
Ceiba	1	180	180
Guayanilla	1	190	190
Mayaguez	1	170	170
Salinas	1	200	200
San Juan	1	180	180
Toa Baja	1	180	180
Villalba	1	180	180

Table 3-62. Number of PREPA transmission centers exposed to risk according to category IV.

Municipality	Frequency	Winds Max.	Winds Min.
San Juan	4	180	180
Ponce	3	180	180
Humacao	2	180	180
Añasco	1	170	170
Aguadilla	1	170	170
Aguas Buenas	1	180	180
Arecibo	1	170	170
Barceloneta	1	170	170
Bayamón	1	180	180
Cabo Rojo	1	170	170

Number of shelters exposed to risk.

The largest number of shelters exposed to the risk of extreme winds (according to category IV) is in San Juan, with a total of 40. Then, decreasing the number of shelters, are the towns of Ponce (27), Caguas (12), Utuado (12), Arecibo (1), Yauco (11), Florida (10), Guaynabo (10), Salinas (10) and Manatí (9). See **Table 3-63 - next page.**

Table 3-63. Number of shelters exposed to risk according to category IV.

Municipality	Frequency	Max. Winds Cat. IV	Winds Min. Cat. IV
San Juan	40	210	180
Ponce	27	190	180
Caguas	12	190	180
Utuado	12	190	170
Arecibo	11	180	170
Yauco	11	210	180
Florida	10	180	170
Guaynabo	10	180	180
Salinas	10	200	180
Manatí	9	180	170

Table 3-64. Number of schools exposed to risk according to category IV.

Municipality	Frequency	Max. Winds Cat. IV	Winds Min. Cat. IV
San Juan	139	210	180
Ponce	111	230	180
Bayamón	67	200	180
Caguas	53	240	180
Arecibo	47	190	-
Carolina	46	220	180
Mayagüez	43	230	170
San Sebastián	34	190	170
Yauco	32	250	180
Humacao	31	240	180

Number of Telecommunication Antennas Exposed to Risk.

Telecommunication antennas have historically proven to be one of the most vulnerable infrastructures to the risk of extreme winds. Due to the passage of the 2017 hurricanes, about 85% of these antennas were knocked down, leaving the population uncommunicative. This limits the communication of information between individuals and between agencies with the general population. The largest number of cellular antennas exposed to the risk of extreme winds (according to category IV) is in Aguadilla and San Juan with a total of 4 antennas per municipality. Añasco, Arecibo, Cabo Rojo, Carolina, Cayey, Culebra, Humacao, and Ponce have 3 antennas in each municipality **(Table 3-65).**

Table 3-65. Number of Telecommunication Antennas Exposed to Risk According to Cat. IV.

Municipality	Frequency	Max. winds Cat. IV	Winds Min. Cat. IV
Aguadilla	4	180	170
San Juan	4	190	180
Añasco	3	210	200
Arecibo	3	200	170
Cabo Rojo	3	200	200
Carolina	3	180	180
Cayey	3	260	250
Culebra	3	230	-
Humacao	3	240	180
Ponce	3	270	180

3.6.4. Potential Hazard: Earthquake (liquefaction and acceleration)

Methodology.

Two layers of the Geographic Information System (GIS), called: Seismic Acceleration or Peak Ground Acceleration (PGA) and Liquefaction were selected to study and describe the earthquake risk profile. The purpose of this is to fully understand the risk scenario in Puerto Rico through two variables: seismic acceleration and liquefaction. The risk assessment on seismic acceleration is based on the magnitude 6.4 earthquake scenario on January 7, 2020, with an epicenter in Barrio Indios, Guayanilla, Puerto Rico (USGS, 2020) **(See Figure 3-38)**. To identify the most exposed municipalities, a "Summary" was created in ArcGIS Pro and according to the frequency of the "Severe" and "Very Strong" categories in the "census track" and the total population that would be affected by "Severe" and "Very Strong" seismic acceleration, the ten (10) most exposed municipalities in seismic acceleration were chosen, placing in the first place those with "Severe" seismic acceleration and then those with "Very Strong" seismic acceleration.

Figure 3-38. USGS Seismic Acceleration Map.

In the case of the liquefaction layer, to choose the ten (10) most exposed municipalities in "Very High" liquefaction, the total of the most affected population was used, since in the "Very High" liquefaction category, using the census track frequencies, these were not following the total affected population. For this reason, to list the municipalities that represent a greater exposure, the total of the most affected population was used as a guide to choose the ten (10) most exposed municipalities in this liquefaction risk.

It is important to note that the liquefaction layer is not based on the January 7, 2020 event, as the seismic acceleration. This liquefaction layer does not contain metadata, and the parameters that were carried out to assign the different categories of liquefaction in Puerto Rico are unknown. The layer already included categories such as Very Low Liquefaction, Low Liquefaction, Moderate Liquefaction, High Liquefaction, and Very High Liquefaction. It was with these previously established categories that the different analyses were performed.

The ten (10) municipalities with the most significant exposure to Severe and Very Strong Seismic Acceleration from the M 6.4 earthquake event of January 7, 2020, with epicenter in Barrio Indios, Guayanilla, Puerto Rico, are:

Table 3-66. Relation between Local Governments and Seismic Acceleration.

Municipality	Exposure to Seismic Acceleration
Yauco	Severe
Peñuelas	Severe
Guánica	Severe
Guayanilla	Severe
Ponce	Severe
Sabana Grande	Severe
Adjuntas	Very Strong
Utuado	Very Strong
Lajas	Very Strong
Jayuya	Very Strong

Regarding the secondary liquefaction risk, the ten (10) most exposed municipalities in Very High liquefaction based on the total population most affected are:

Table 3-67. Relation between Local Governments and Liquefaction.

Municipality	Exposure to Seismic Acceleration
Arecibo	Very High
Mayagüez	Very High
Aguada	Very High
San Juan	Very High
Toa Baja	Very High
San Germán	Very High
Bayamón	Very High
Dorado	Very High
Aguadilla	Very High
Vega Baja	Very High

On the other hand, in addition to specifying the most exposed municipalities, graphs were also generated with Puerto Rico exposure at the state level. The risk area (seismic acceleration and liquefaction) was divided by the census-tract area. The result was multiplied by the total population, then by the total population of people aged 65 years or older, the total population of people aged 16 years or older, the total Population of women in charge of the household, total population of people with functional diversity, and total households with income less than $10,000 per year. Each column was created in the attribute table of the feature classes named: "Liquefaction_Intersect_CT" and "pga_Identity_CT. This was done in this way to normalize the demographic and socioeconomic data with the population affected by the risk. That is, the population was adjusted to the respective risks.

Social Vulnerabity Assessment on Seismic Acceleration.

The total statewide Population of Puerto Rico will be indicated, followed by the most exposed municipalities. This order will be the same for both seismic acceleration risk and liquefaction risk. The purpose is to know the most vulnerable population at risk at the state level and then at the municipal level.

The profile of the exposed population is defined from data retrieved from the 2014-2018 Puerto Rico Community Survey. The demographic and socioeconomic variables used from the Survey for these risks are total population, the total population of persons 65 years of age or older, total population of persons 16 years of age or older, total Population of female household heads, total Population of persons with functional diversity, and total households with income less than $10,000 per year.

The evaluation of the total population by acceleration category identifies that "Moderate" seismic acceleration put 2,427,542 people at risk, "Strong" acceleration put 536,852 people at risk, "Very Strong" acceleration put 217,127 people at risk, "Mild" seismic acceleration put 122,581 people at risk and "Severe" seismic acceleration put a total of 82,775 people at risk.

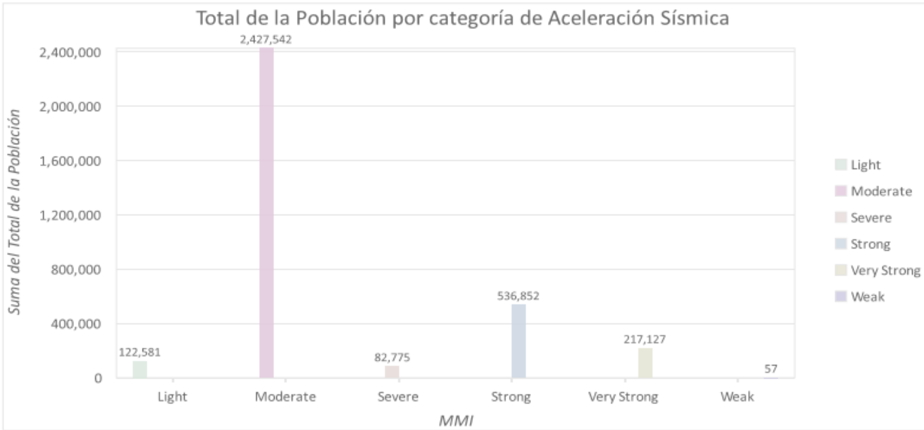


Figure 3-39. Total Population by Seismic Acceleration Category.

In evaluating acceleration risk by municipality, the municipality of Yauco has the largest total population exposed to "Severe" seismic acceleration, with 30,275 people. The other municipalities in this category are Guayanilla, Guánica, Peñuelas, and Ponce. The municipality of Ponce has the highest population total with 127,399 people in the "Very Strong" seismic acceleration. The other municipalities in this category are Sabana Grande, Utuado, Adjuntas, and Peñuelas. (**Figure 3-40**).

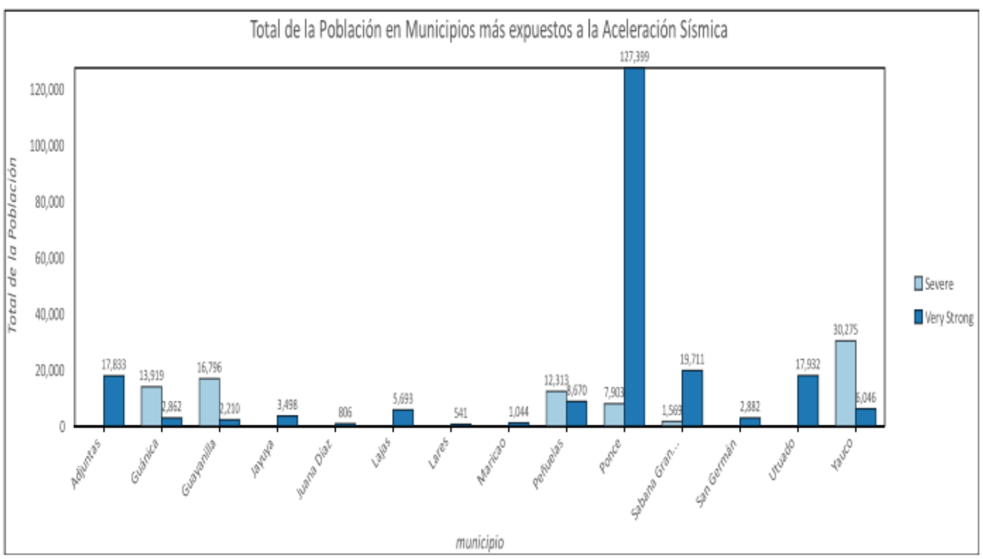


Figure 3-40. Total of Population in Local Governments.

Of the population aged 65 years or older exposed to this event's seismic acceleration at the state level, the majority was in the "Moderate" seismic acceleration category with an estimated total of 453,018 elderly people **(Figure 3-41).** The profile of people aged 65 years or older identified that 103,928 people witnessed "Strong" acceleration; 44,173 people witnessed "Very Strong" acceleration, and 23,888 people witnessed "Mild" acceleration and in "Severe" seismic acceleration it is estimated that there are 15,597 elderly people exposed.

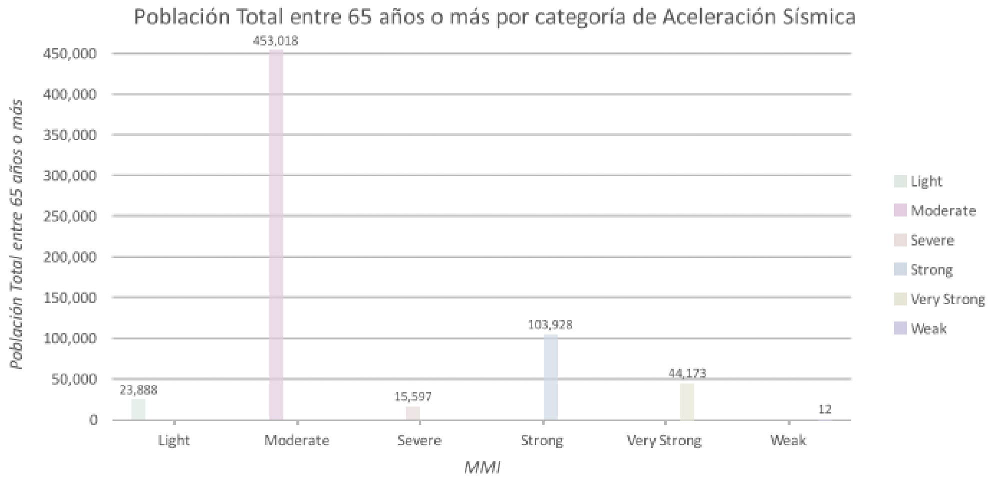


Figure 3-41. Total Population 65 years and older by Seismic Acceleration Category.

Regarding the analysis at the municipal level of the total population aged 65 years or older, the municipality with the highest total population in "Very Strong" seismic acceleration is Ponce, with an estimated 26,084 exposed elderly. Other municipalities with a high population in "Very Strong" seismic acceleration are Sabana Grande, Utuado, Adjuntas, and Peñuelas. Under the "Severe" seismic acceleration category is Yauco, with an estimated total of 6,201 elderly, and other municipalities in this same category are Guayanilla, Guánica, Peñuelas, and Ponce (**Figure. 3-42**).

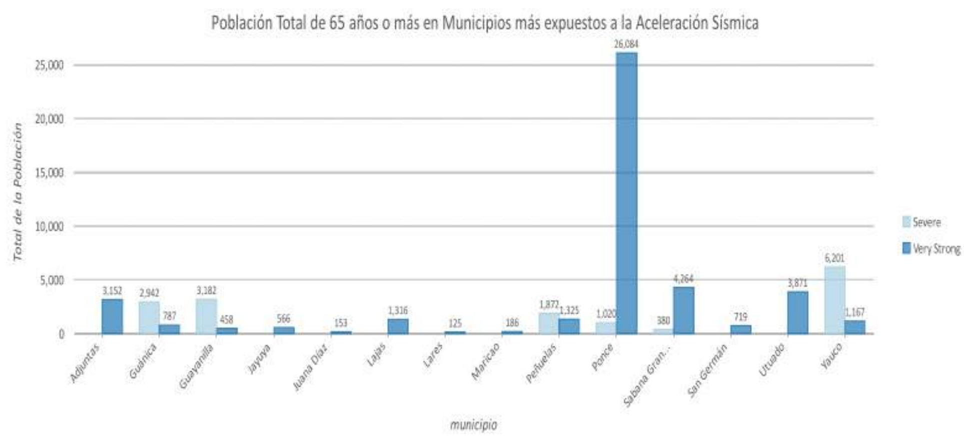


Figure 3-42. Total Population aged 65 years and over in municipalities.

On the other hand, the total population aged 16 and under at the state level is dominated by the "Moderate" category with an estimated 424,225. Then, the next categories in order affecting the state level are "Strong," "Very Strong," "Mild," "Severe," and, lastly, "Weak." In "Severe" seismic acceleration, there is a total of 15,160 population aged 16 years or less exposed to the most severe seismic acceleration (**Figure 3-43**).

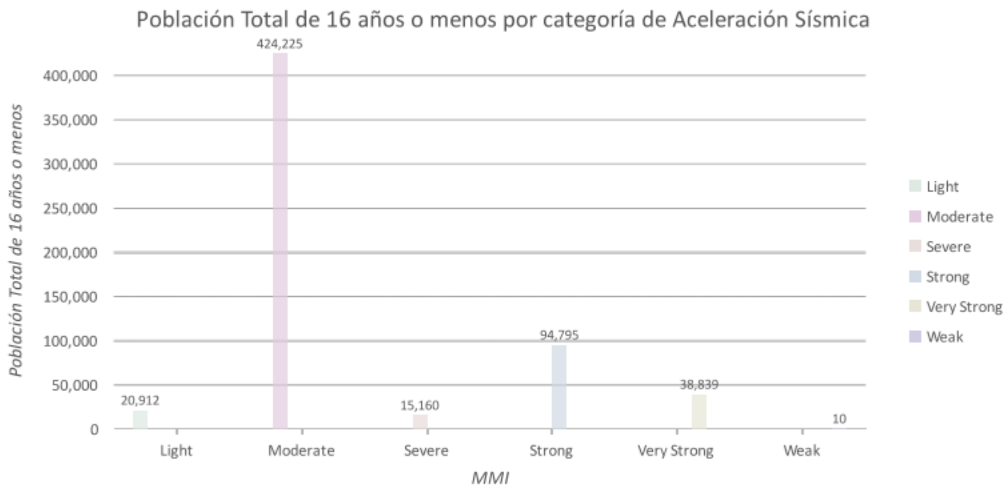


Figure 3-43. Total Population 16 years old or younger by Seismic Acceleration category.

The municipality with the largest Population 16 years of age or younger is Ponce, with an estimated 23,163 exposed to "Very Strong" seismic acceleration. Also, in the "Very Strong" category in seismic acceleration with a high population of adolescents and minors are municipalities such as Sabana Grande, Adjuntas, Utuado, and Peñuelas. In comparison, in the "Severe" seismic acceleration category, the largest number is found in Yauco, with an estimated total of 5,446 people 16 years of age or younger. The other municipalities in the severe category with a high population of this Population are Guayanilla, Guánica, Peñuelas, and Ponce. (**Figure 3-44**)

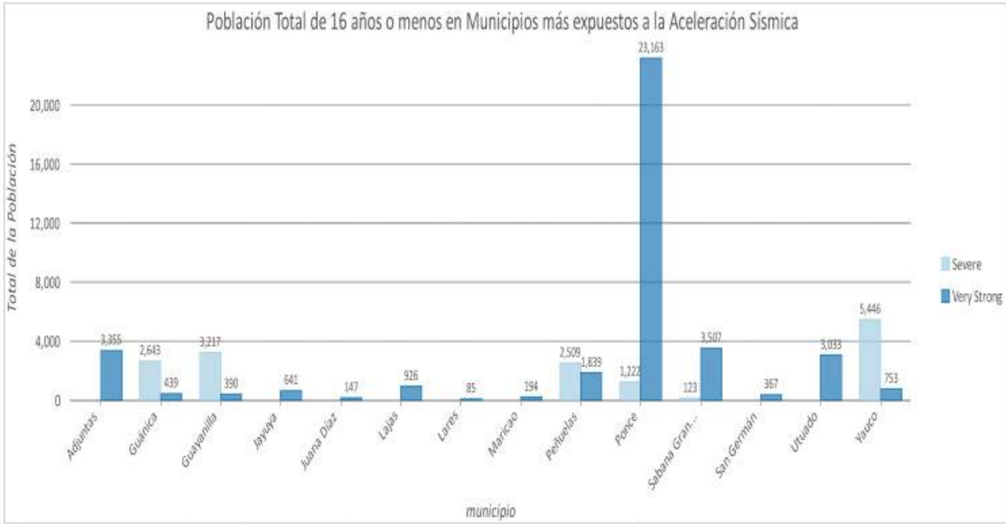


Figure 3-44. Total population aged 16 years or less in Municipalities.

The total number of households with incomes less than $10,000 per year at the state level is dominated by the "Moderate" category with a total of 17,052 households. The order of the other categories is "Strong," "Very Strong," "Mild," "Severe," and "Weak." In the "Severe" seismic acceleration, the total number of households with incomes below $10,000 is: 817 households. (**Figure 3-45**).

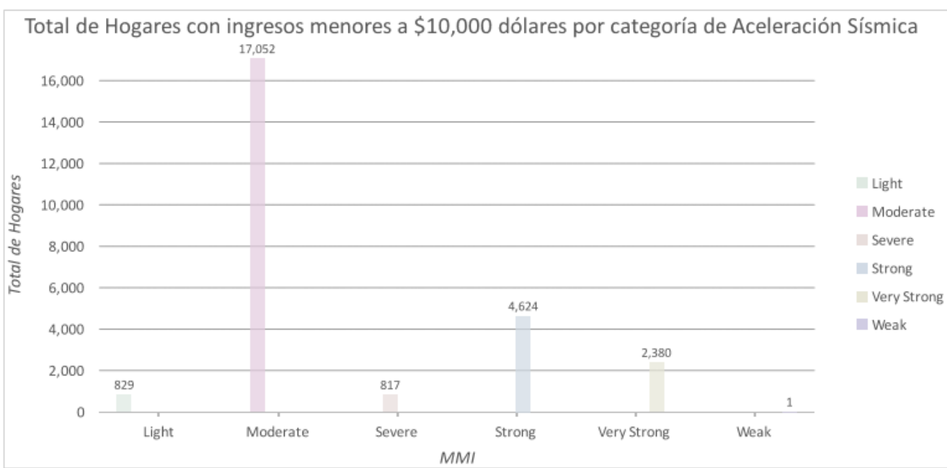


Figure 3-45. Total Households with Income less than $10,000 per year at the State Level.

Of the total number of households with incomes of less than $10,000 per year, the municipality of Ponce is "Very Strong" seismic acceleration has 1,414 households with incomes of less than $10,000 per year. Then, in the same category, the following municipalities continue Adjuntas, Utuado, Sabana Grande, and Yauco. On the other hand, in "Severe" seismic acceleration, the municipality with the highest total number of households is Yauco, with a total of 314 households. The other municipalities with "Severe" seismic acceleration are Guánica, Guayanilla, Peñuelas, and Ponce. (**Figure 3-46**).

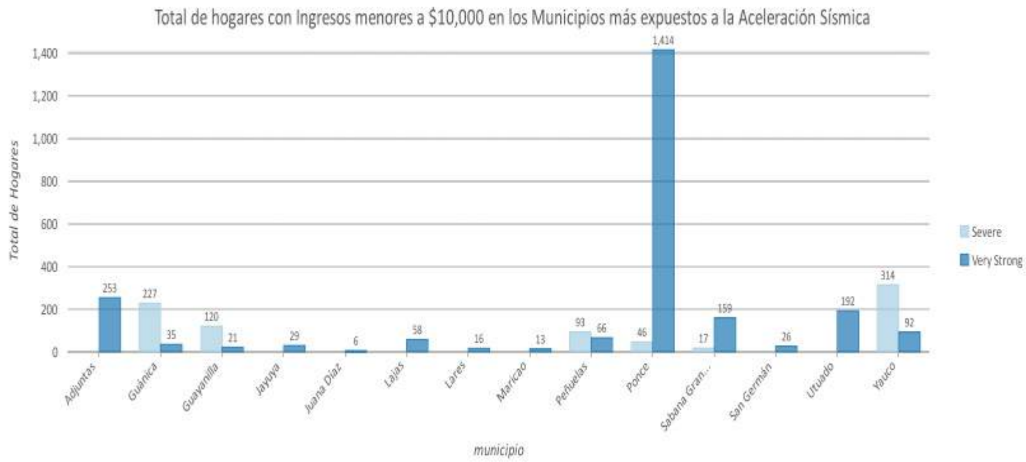


Figure 3-46. Total households with income under $10,000 in municipalities.

The total population with functional diversity at the state level predominates in the "Moderate" seismic acceleration with an estimated 521,099 people with functional diversity. The order of the other categories at the state level is: "Strong," "Very Strong," "Mild," "Severe," and ends with "Weak." In "Severe" seismic acceleration, there is an estimated total of 18,924 people with functional diversity at the state level. (**Figure 3-47**).

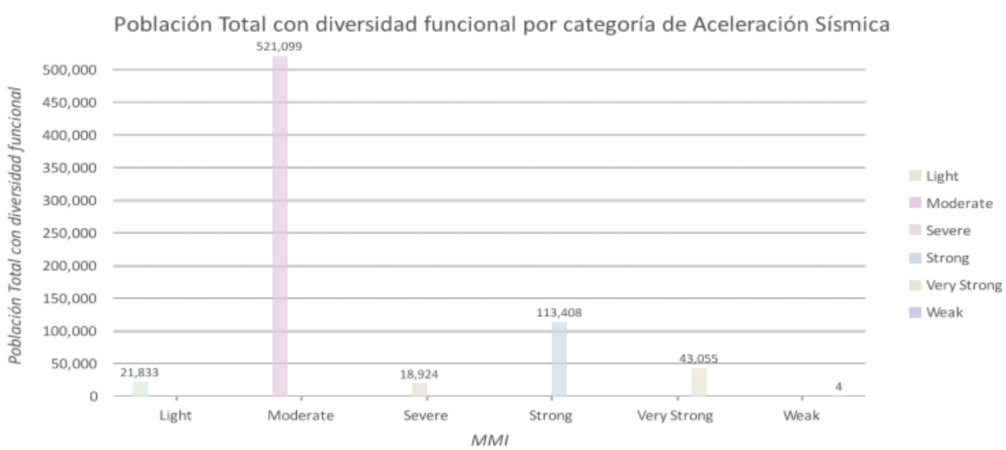


Figure 3-47: Total Population with functional diversity by Seismic Acceleration category.

The municipality of Ponce has the highest number with a total of 22,398 people with functional diversity in "Very Strong" seismic acceleration. The other municipalities with a high population with functional diversity are Sabana Grande, Adjuntas, Utuado, and Yauco. In comparison, in "Severe" seismic acceleration, the municipality with the highest number of this Population is Yauco, with 8,530 people with functional diversity.

The other municipalities in "Severe" seismic acceleration with a high population of people with functional diversity are Guánica, Guayanilla, Peñuelas, and Sabana Grande. (**Figure 3-48**).

Figure 3-48. Total population with functional diversity in municipalities.

At the state level, the total number of women in charge of the household predominates in the "Moderate" seismic acceleration. A total of 206,828 women in Puerto Rico in the head of the household. The order of the next categories is: "Strong," "Very Strong," "Mild," "Severe," and "Weak." In the "Severe" seismic acceleration, there are a total of 5,645 women in charge of the household. **(Figure 3-49).**

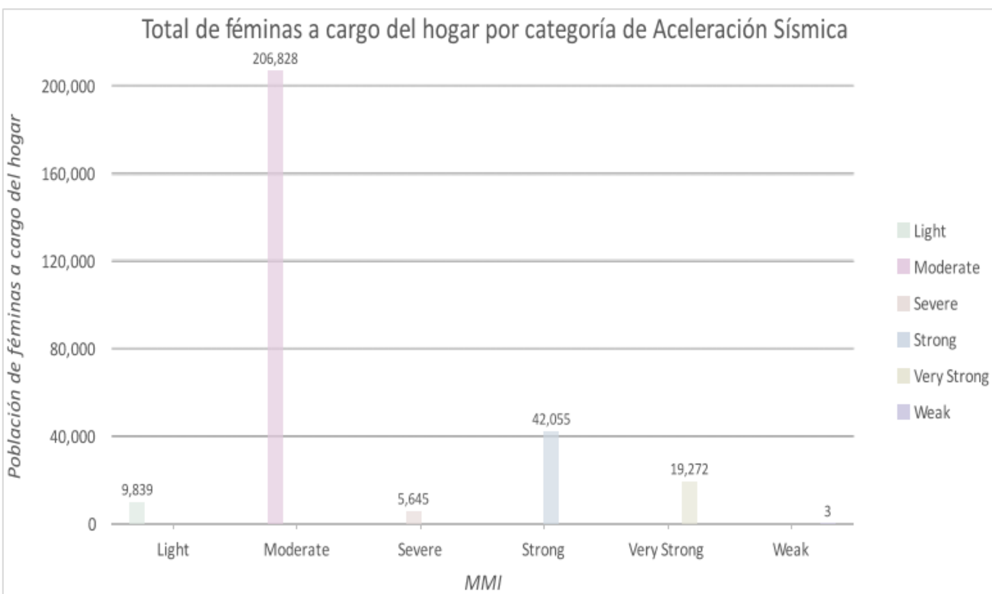


Figure 3-49. Total female household population by Seismic Acceleration category.

In terms of the total population of women in charge of the household, the municipality with the highest total of this population in "Very Strong" seismic acceleration is Ponce, with 12,565 women in the head of the household. The other municipalities in "Very Strong" seismic acceleration and that have a high total of this type of Population are Sabana Grande, Adjuntas, Peñuelas, and Jayuya. In comparison, in "Severe" seismic acceleration, the municipalities with the highest numbers are Yauco, Guayanilla, Guánica, Peñuelas, and Ponce. **(Figure 3-50).**

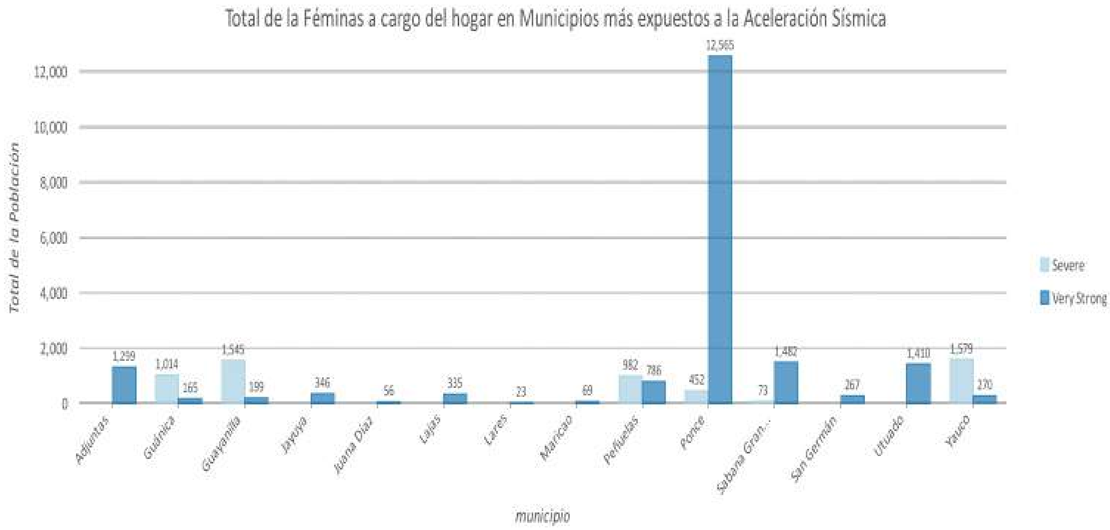


Figure 3-50. Total population of female heads of household in municipalities.

According to the breakdown of the information extracted from the previous graphs, it is indicated that the seismic acceleration that predominates is "Moderate" in all the mentioned population types regarding the state level. The order of the other categories is "Strong," "Very Strong," "Slight," "Severe," and "Weak." At the state level, the "Severe" category does not rank fourth in the seismic acceleration categories, and the total populations are not perceived as a very high one. Likewise, although severe seismic acceleration seems insignificant or insignificant at the state level, it is imperative to manage it from the municipalities to mitigate the risks and disasters in a future seismic event.

The municipality of Ponce has the highest number of different types of populations about "Very Strong" seismic acceleration. On the other hand, the municipality of Yauco, although it does not have the Population of Ponce, is the municipality with the highest total of the different types of population, but in the "Severe" seismic acceleration. Although Ponce has a larger population, it is the municipality of Yauco in a position with a higher probability of disasters and landslides since its "Severe" seismic acceleration. Its population is the highest compared to the other municipalities in the "Severe" category of seismic acceleration.

Social Vulnerability Assessment on Liquefaction.

For the analysis at the state level and in the municipalities of Puerto Rico in liquefaction, the different types of population (for example, the total number of women in charge of the household, the total number of persons with functional diversity, among others) in all of Puerto Rico will be presented, and then the municipalities that are in the "Very High" liquefaction category and their total population. Each municipality represents a certain degree of exposure to "Very High" liquefaction. The purpose is to know the most vulnerable population at risk at the state and municipal levels in Puerto Rico.

However, the total population by levels of liquefaction at the state level presents a majority in the "Very Low Liquefaction" category, with a total of 1,885,031 people at low risk. This is followed by the "Low," "High," "Moderate," and "Very High" categories. This last category has a total of 97,796 people in high-risk areas (**Figure 3-51**).

Figure 3-51. Total population by liquefaction levels.

The total population in municipalities most exposed to liquefaction "Very High" is the municipality of Arecibo, with 11,140. This is followed by Mayagüez (7,124), Aguada (6,999), San Juan (6,616), and Toa Baja (5,322), all of which present severe liquefaction risks according to the geological characteristics of the areas. The municipalities with the least exposure to liquefaction are in the mountainous region (**Figure 3-52**).

Figure 3-52. Total population by liquefaction levels in municipalities.

Comparing the total sum of the population aged 65 years and older by levels of liquefaction shows a clear majority in the "Very Low" category, with a total of 405,138. This is followed by the categories "Low," "High," "Moderate," and "Very High." This last category has a total of 20,629 people in high-risk areas (**Figure 3-53**).

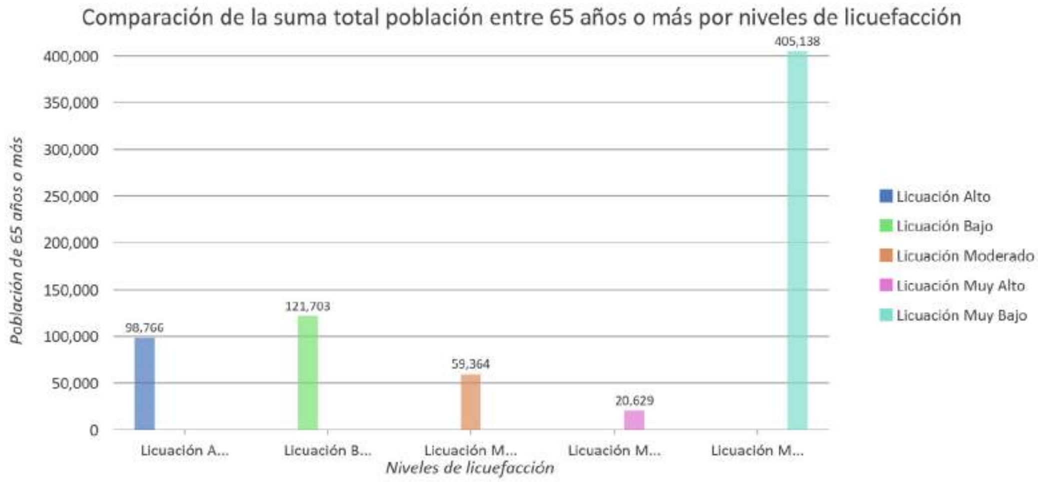


Figure 3-53. Total population 65 years and older by liquefaction levels.

The following graph shows the total number of people 65 years of age and older in the municipalities most exposed to liquefaction. The municipality of Arecibo is the most affected (2,319) by far. The following municipalities are Mayagüez (1,451), San Juan (1,326), Aguada (1,266), and San German (1,026) (**Figure 3-54**).

Figure 3-54: Total Population 65 years of age and older by liquefaction levels in municipalities.

The total population aged 16 years and older by liquefaction levels affected by liquefaction is "Very Low," with a total of 329,662. The rest of the order of categories is "Low," "High," "Moderate," and finally "Very High." The "Very High" liquefaction category affects 16,840 people. (**Figure 3-55**).

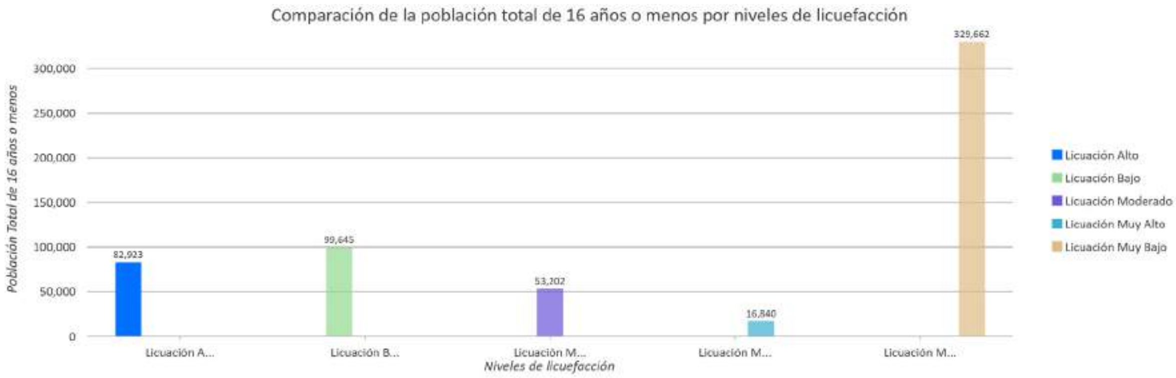


Figure 3-55. Total Population aged 16 and under by liquefaction levels.

The municipality of Arecibo, with a total of 1,865, is the municipality most exposed to liquefaction, 16 years of age or younger. They are followed by the municipalities of Mayagüez (1,303), Aguada (1,214), Toa Baja (918), and Dorado (838). (**Figure 3-56**).

Figure 3-56. Total Population 16 years of age or younger by levels of liquefaction in municipalities.

The total number of households with incomes less than $10,000 per year affected by "Very Low" liquefaction at the state level is the highest at 12,235 total households. The rest of the order of categories is "Low," "High," "Moderate," and "Very High." The "Very high" liquefaction category affects 934 households with incomes below $10,000. (**Figure 3-57**).

Figure 3-57. Total households with incomes less than $10,000 by liquefaction levels.

The following graph corresponds to the total number of households with less than $10,000 per year in municipalities most exposed to liquefaction. The municipality of San Juan has the highest number of households (157). This is followed by the municipalities of Arecibo (127), Aguadilla (107), Toa Baja (64), and Mayagüez (57). Although San Juan has fewer areas with a high risk of liquefaction, there is a greater population concentration in these areas that are affected. (**Figure 3-58**).

Figure 3-58. Total households by liquefaction levels in municipalities.

Figure 3-59 compares the total functional diversity gap by liquefaction levels, with the "Very Low" category having the highest number with a total of 405,138 people in low hazard areas. This is followed by "Low," "High," "Moderate," and "Very Low" liquefaction. The total number of people with functional diversity at high risk is 20,629.

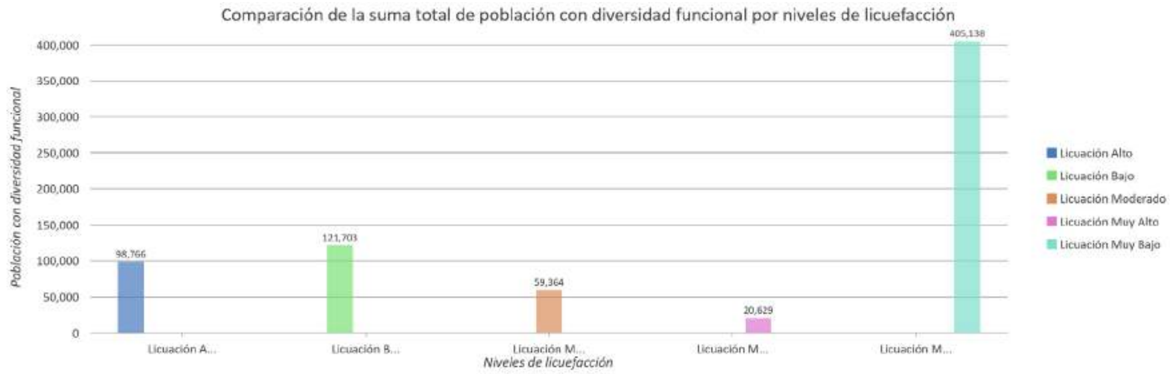


Figure 3-59 Total number of people with functional diversity by levels of liquefaction.

The total population with functional diversity in the municipalities most exposed to liquefaction is the municipality of Arecibo (2,205), followed by Aguada (2,089). The following municipalities are Mayagüez (1,646), Toa Baja (1,408), and Bayamón (1,154). (**Figure 3-60**).

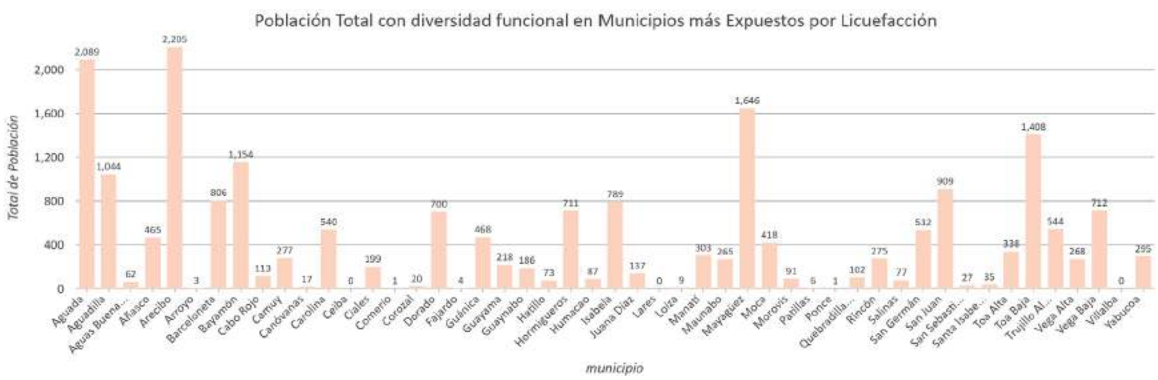


Figure 3-60. Total number of people with functional diversity by levels of liquefaction in municipalities.

Comparing the total number of women in charge of the household by the level of liquefaction shows a clear majority in the "Very Low Liquefaction" category, with a total of 144,855. It is followed by the categories "Low," "High", "Moderate", which represent a significant amount of the total. Finally, the "Very High" category has a total of 8,131 female household heads in high-risk areas (**Figure 3-61**).

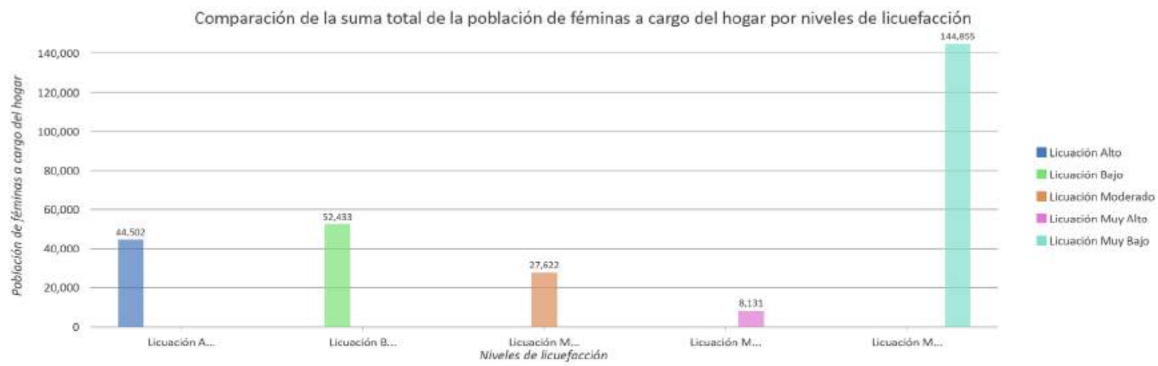


Figure 3-61. Total females in charge of the household by liquefaction levels.

In this graph, the municipality of Arecibo, with 1,000 people, is the municipality most exposed to liquefaction, with the highest number of women in charge of the household in the municipalities with the highest risk of liquefaction. This is followed by the municipalities of Mayagüez (698), San Juan (527), Toa Baja, and Aguadilla (489), which present severe liquefaction risks according to the geological characteristics of the areas. (**Figure 3-62**).

Figure 3-62. Total females in charge of the household by levels of liquefaction in municipalities.

According to the breakdown of the information extracted from the previous graphs, a scenario can be obtained at the state and municipal level of the liquefaction affecting Puerto Rico. At the state level, the predominant level of liquefaction is in the "Very Low" category in all the population types mentioned, and the order of the other categories is "Low," "High," "Moderate," and "Very High."

Regarding the municipalities most exposed to liquefaction in Puerto Rico, the municipality of Arecibo has the largest number of different populations related to "Very Low" liquefaction. Also, municipalities such as Mayagüez, Toa Baja, and San Juan tend to have the highest population.

Seismic Acceleration Infrastructure Analysis.

The following is an assessment of the level of risk to infrastructure in the event of seismic acceleration from the M 6.4 event of January 7, 2020, in Puerto Rico. This analysis is at the state level and allows us to know the different infrastructures at risk if an event like January 7, 2020, occurs.

To have a scenario of the roads in Puerto Rico in the event of risk such as seismic acceleration, the different categories' averages are shown in the graph. The highest standard in linear meters of roads is found in the "Strong" seismic acceleration. In the "Severe" acceleration, there is an average of 203.19871 linear meters of roads exposed (**Figure 3-63**).

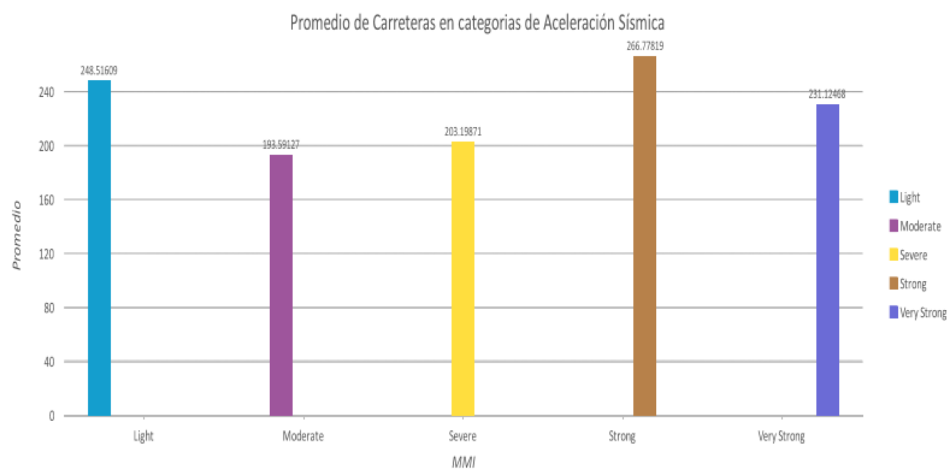


Figure 3-63. Average distance of total roads exposed to seismic acceleration.

To identify the scenario of state highways at risk of seismic acceleration, the average of linear meters for each category was taken, with the average of the mild category being the highest. The average amount of infrastructure that could be most affected is 1,095.5735 linear meters of state highways at "Severe" seismic acceleration. (**Figure 3-64**).

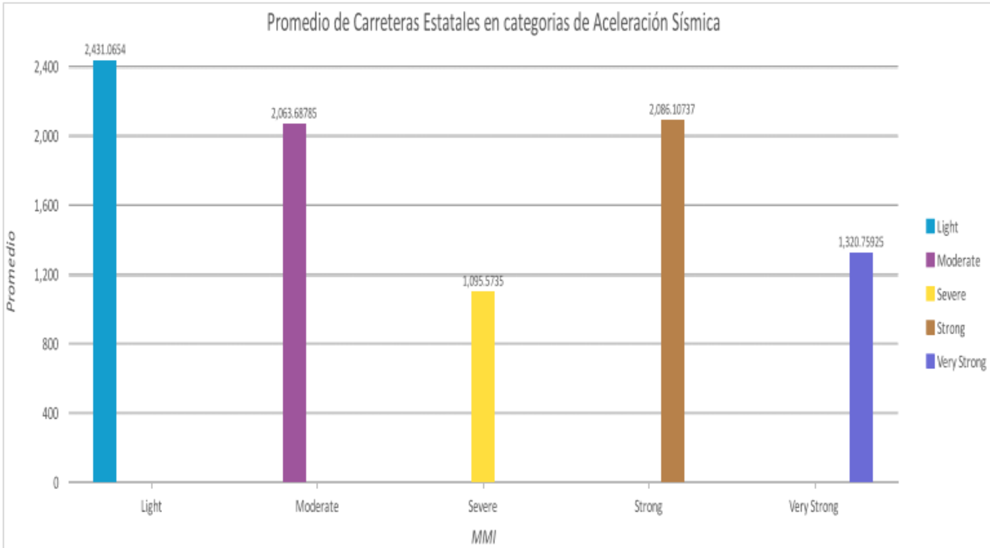


Figure 3-64. Average distance of total state highways exposed to seismic acceleration.

Regarding the PRASA's sanitary lines, the linear meters in each category of seismic acceleration were added up, with the "Moderate" having the most considerable amount, showing a total of 6,088,329.2128 linear meters. While in "Severe" acceleration, 206,750.4871 linear meters are exposed to structural damage (**Figure 3-65**).

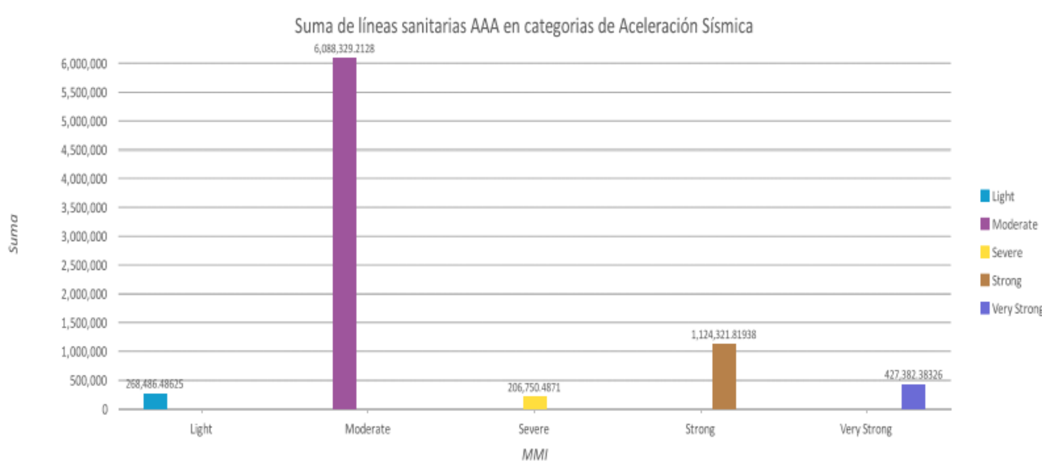


Figure 3-65. Total PRASA Sanitary Lines exposed to seismic acceleration.

For PRASA's sanitary pumping lines, the largest number of linear meters is in the "Moderate" seismic acceleration category. The second-highest number of lines is in the "Strong" seismic acceleration category with a total of 186,593.6793 linear meters. As for the "Severe" category, there is a sum of 32,685.64924 linear meters exposed to a greater probability of damage due to the type of acceleration. (**Figure 3-66**).

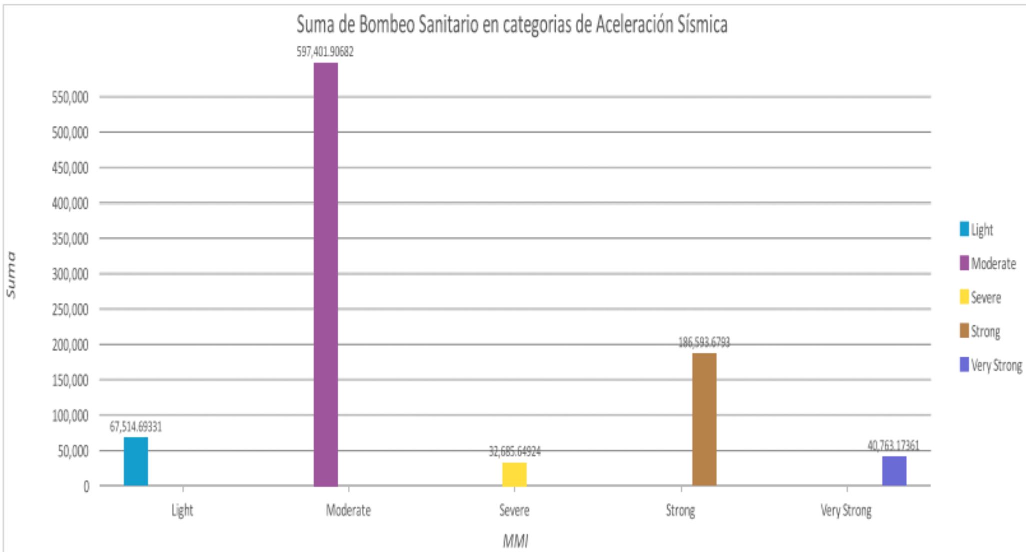


Figure 3-66. PRASA Sanitary Pumping Lines exposed to seismic acceleration.

The average linear meters were calculated for each category. The highest average is in "Very Strong" acceleration, while in "severe" acceleration, the representative value in linear meters is 225.7375 in AAA water lines. (**Figure 3-67**).

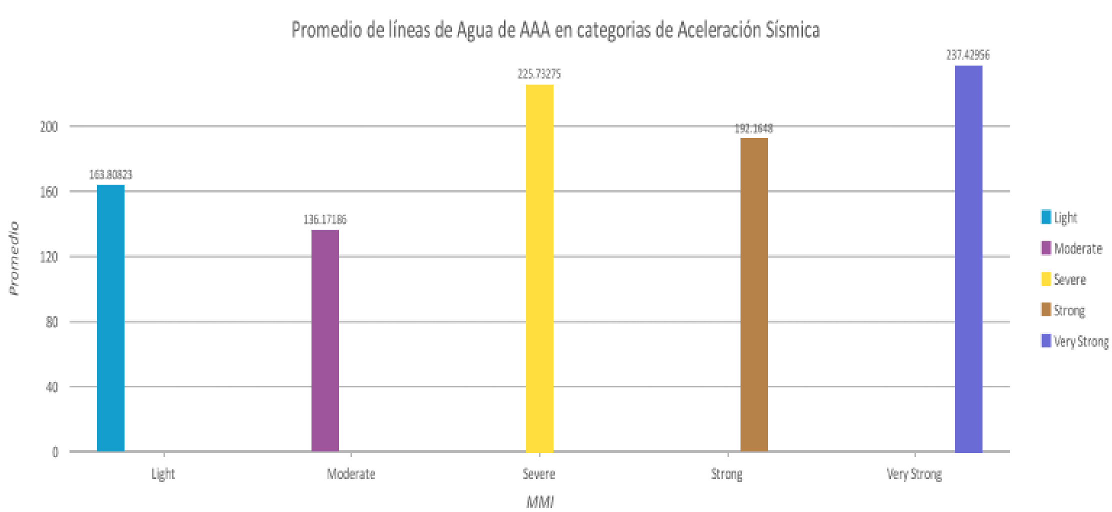


Figure 3-67. PRASA water lines exposed to seismic acceleration.

The largest number of PREPA transmission centers in Puerto Rico are in the "Moderate" seismic acceleration category with 24 centers. In the "Strong" acceleration categories, there are four (4) centers, as well as in "Very Strong" acceleration. In "Severe" seismic acceleration, there is only one transmission center exposed. (**Figure 3-68**).

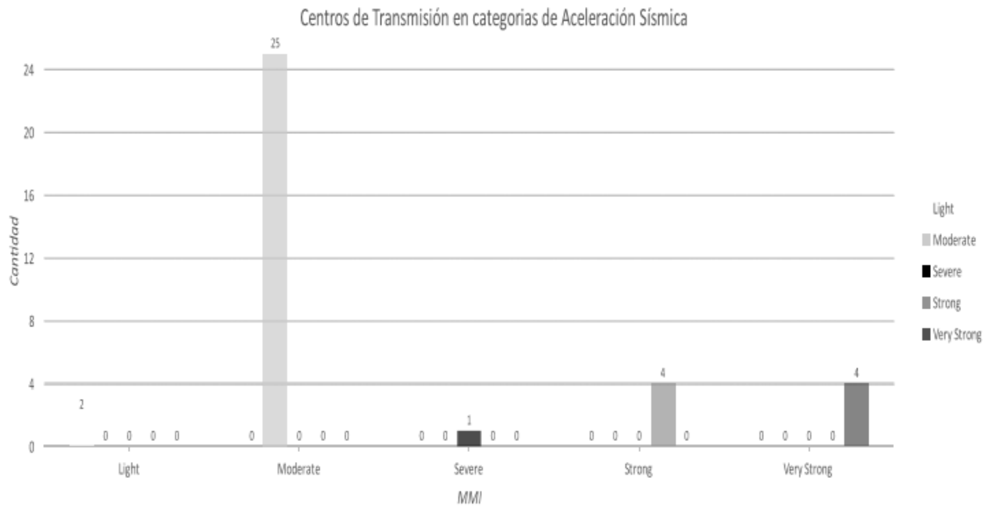


Figure 3-68. PREPA Transmission centers exposed to seismic acceleration.

As for PREPA's electrical substations, most are in the "Moderate" seismic acceleration area with a total of 234 substations. The second area with the most substations is in the "Strong" seismic acceleration area. In the "Severe" acceleration area, there are eleven (11) substations that could have more significant damage in the face of risk **(Figure 3-69).**

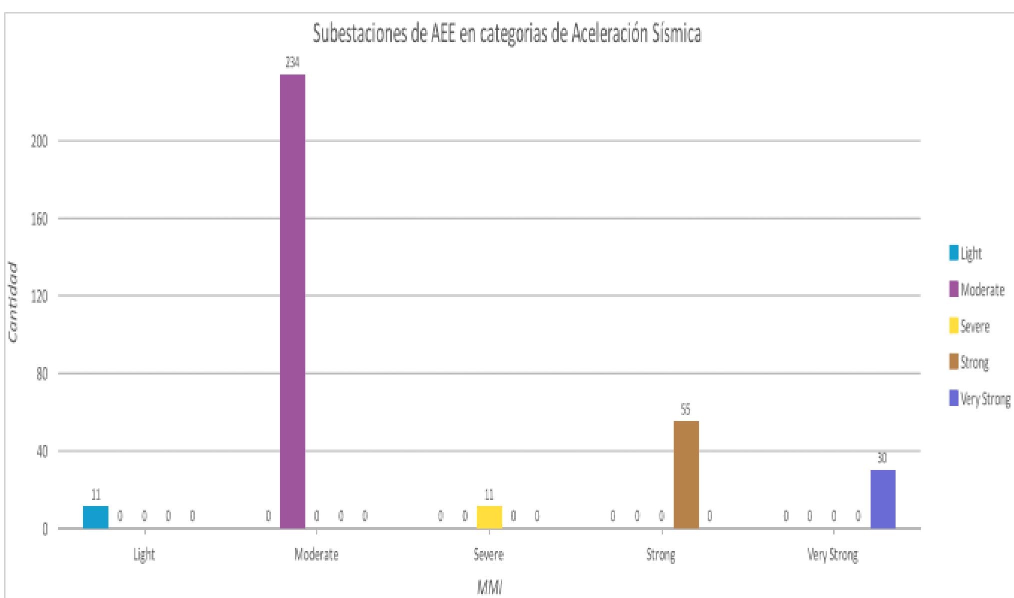


Figure 3-69. PREPA's Electrical Substations exposed to seismic acceleration.

Regarding PREPA's power plants, most of this infrastructure is in "Moderate" seismic acceleration. Also, there are three in "Strong" acceleration and two in "Very Strong" as well as "Severe" acceleration. There are seven power plants located in high seismic acceleration zones that can cause damage their infrastructure **(Figure 3-70).**

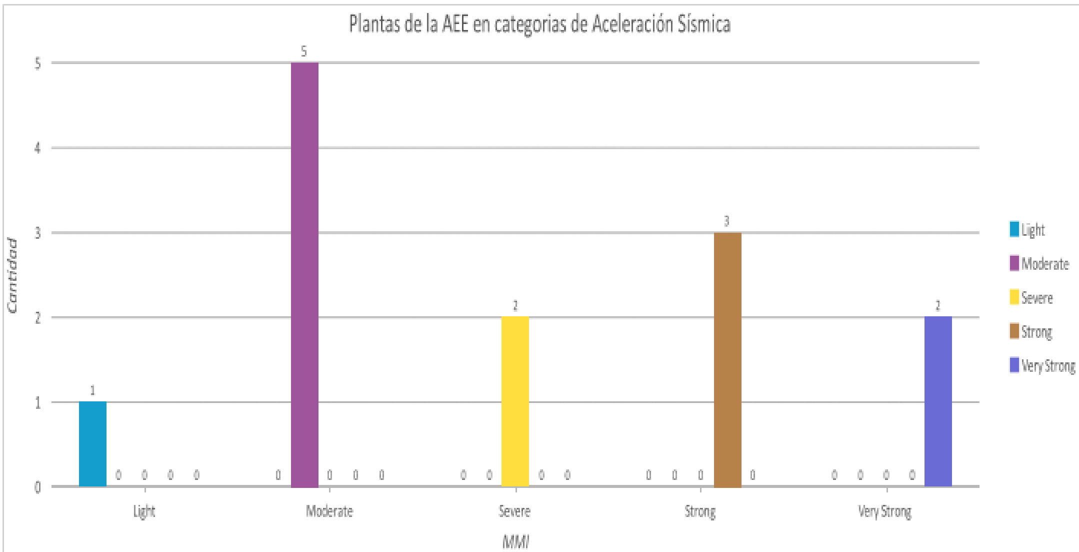


Figure 3-70. PREPA Power Plants exposed to seismic acceleration.

In terms of shelters, most are in the "Moderate" seismic acceleration with a total of two-hundred ninety-two (292) shelters. In the "Severe" acceleration category, there are twenty (20) shelters that are exposed to a higher probability of structural damage upon the occurrence of the risk of seismic acceleration **(Figure 3-71).**

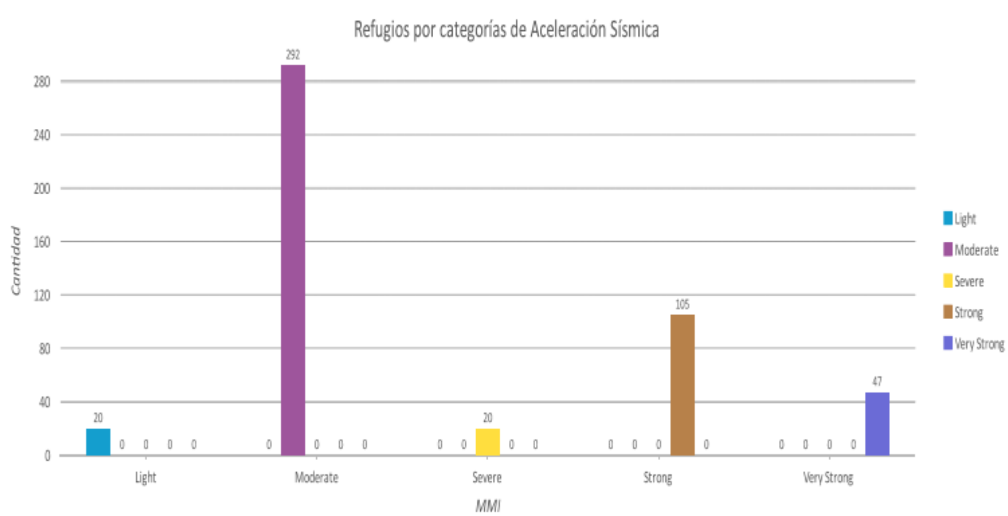


Figure 3-71. Shelters exposed to seismic acceleration.

The number of schools in Puerto Rico may have changed due to school closures, but for this graph, it refers to the physical structure, although there is no information to confirm that these schools are still open. Most of this infrastructure is in the "Moderate" seismic acceleration area with 1,049 schools. In the "Severe" acceleration area, sixty-six (66) schools are exposed. (**Figure 3-72**).

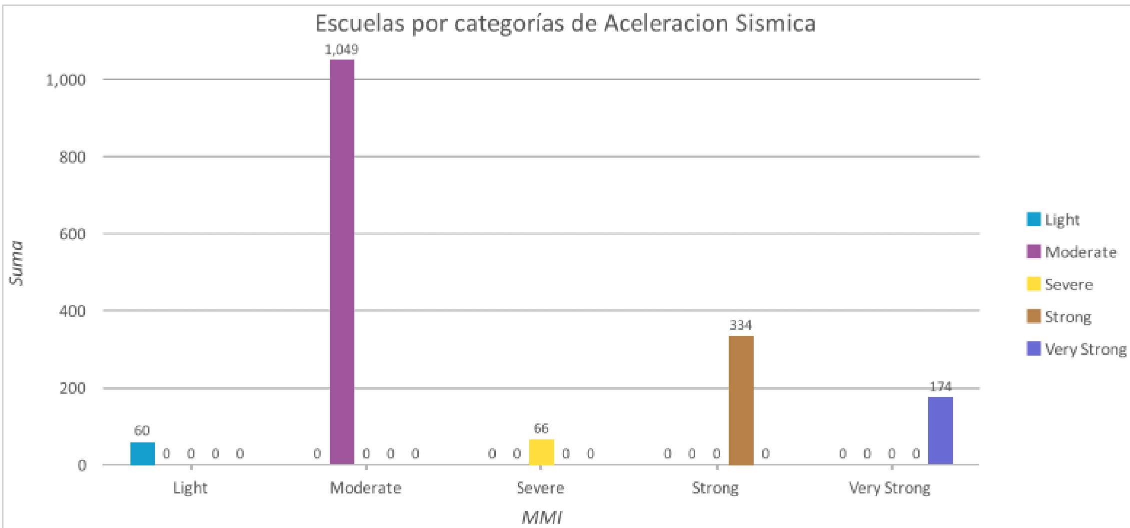


Figure 3-72. Schools exposed to seismic acceleration.

Most of the telecommunication towers (antennas) are in the "Moderate" seismic acceleration category, with a total of forty-seven (47). Only one (1) antenna is in the "Severe" acceleration category (**Figure 3-73**).

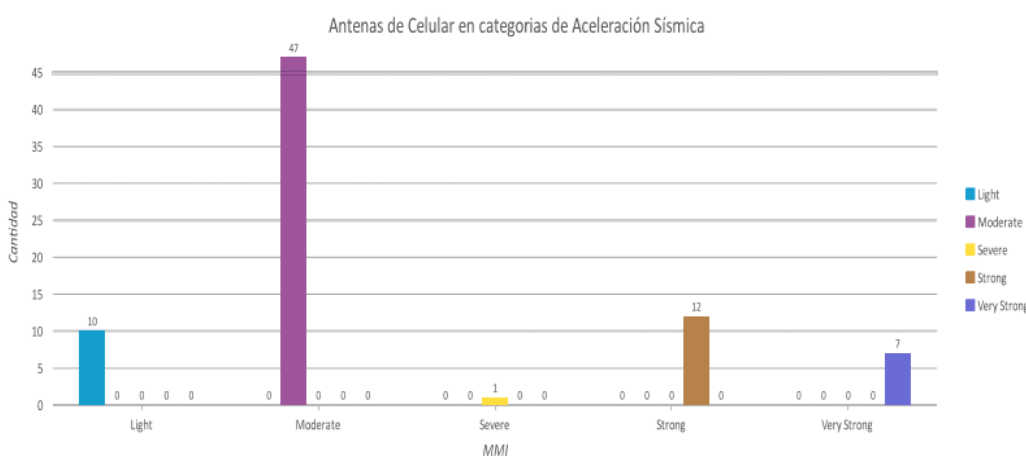


Figure 3-73. Telecommunication Towers (Antennas) exposed to seismic acceleration.

The following is an assessment of the level of risk to infrastructure in the event of liquefaction in Puerto Rico. This analysis is at the state level and provides information on the different infrastructures that could be at risk in the event of a liquefaction event possibly generated by an earthquake on the Island.

The highest average number is found in very low liquefaction with an average of 247.75472 linear meters in terms of roads. The order of the other categories is Very low liquefaction, moderate liquefaction, low liquefaction, and finally high liquefaction (**Figure 3-74**).

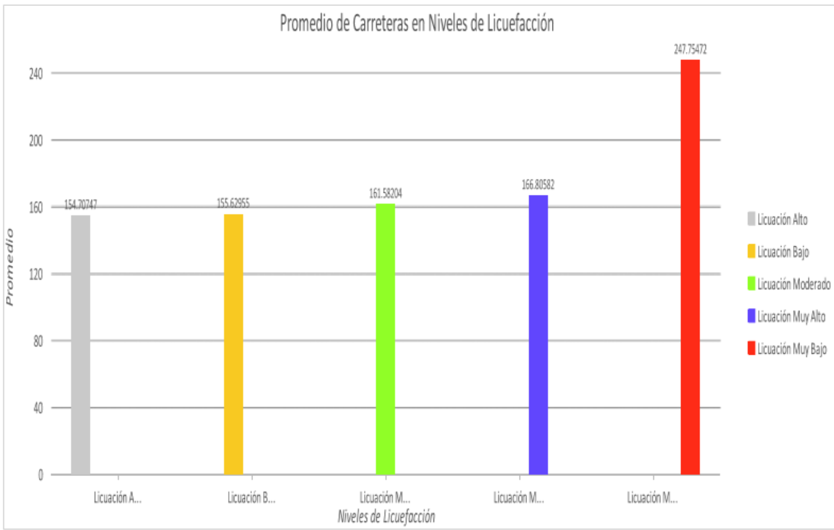


Figure 3-74. Average of roads in liquefaction levels.

In terms of state highways, the highest average in linear meters of roads is found in Very Low liquefaction terrain, with an average of 2,425.28325. Then, the order of the other road averages in the different liquefaction categories is Low liquefaction, High liquefaction, Moderate liquefaction, and Very High liquefaction (**Figure 3- 75**).

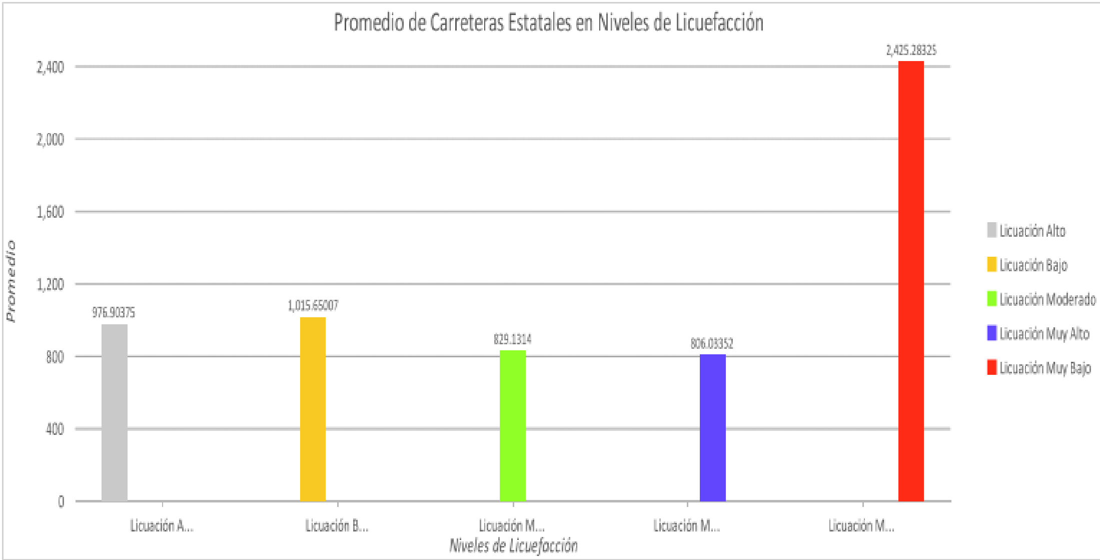


Figure 3-75. Average number of state highways in liquefaction levels.

In terms of the sum of PRASA's sanitary lines, the most considerable amount is found in very low liquefaction with a total of 2,831,678.51734. The order of the other categories is Low liquefaction, High liquefaction, Moderate liquefaction, and very high liquefaction. (**Figure 3-76**).

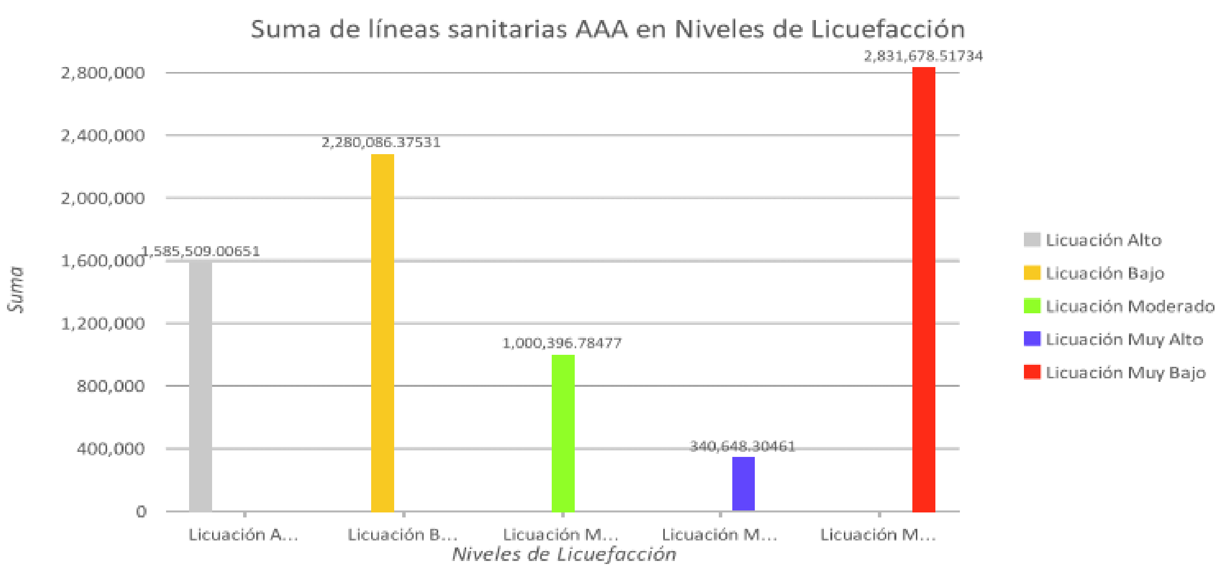


Figure 3-76. Total PRASA sanitary lines in liquefaction levels.

In the case of PRASA's sanitary pumping lines, the greatest amount in the sum of linear meters of these lines is found in very low liquefaction with a total of 334,086.12535. The order of the other categories is low Liquefaction, High liquefaction, Moderate liquefaction, and Very High liquefaction. (**Figure 3-77**).

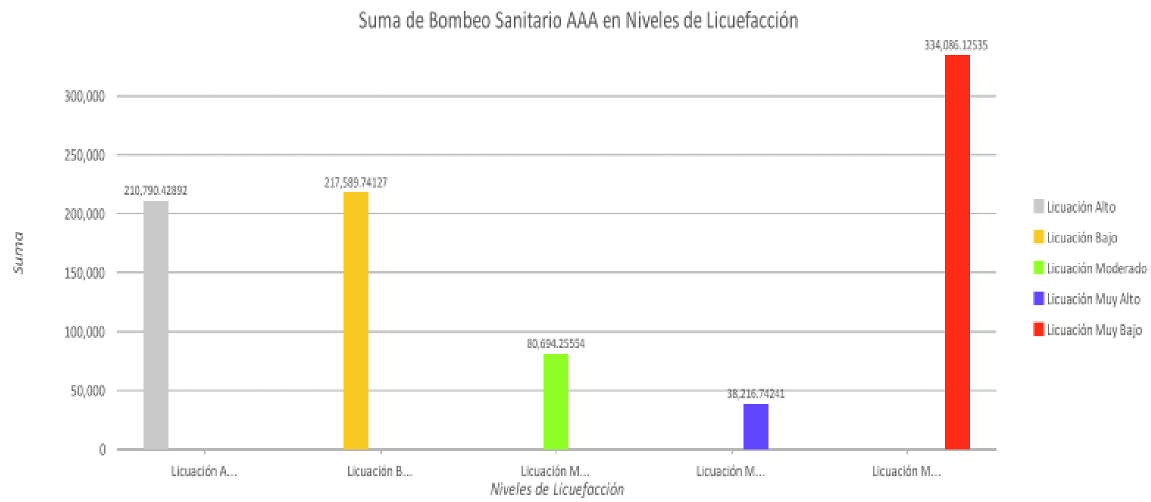


Figure 3-77. Total PRASA Sanitary Pumping lines at liquefaction levels.

About the average number of PRASA's water lines, the highest average is found in Very Low liquefaction terrain with 182.96243 linear meters. The other categories' order is moderate liquefaction, Very High liquefaction, Low liquefaction, and High liquefaction. (**Figure 3-78**).

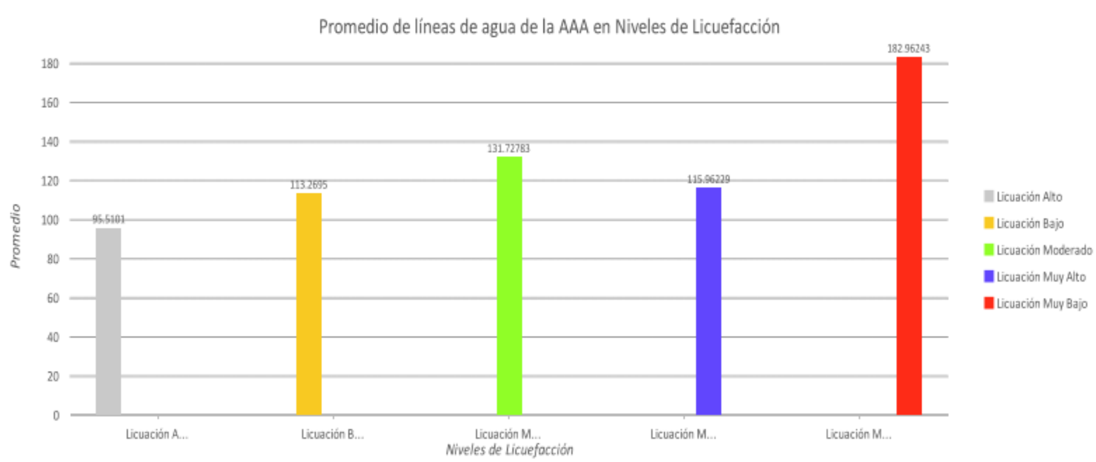


Figure 3-78. Average PRASA water lines at liquefaction levels.

The PREPA's transmission centers usually are in areas classified as Very Low liquefaction with eleven (11) centers. Then, there are eight (8) centers in High Liquefaction and eight (8) in Low liquefaction. In Moderate liquefaction, there are six (6) and in Very High liquefaction, there are a total of three (3) substations. If the facilities in the High and Very High categories are added, a total of eleven (11) facilities are at risk of liquefaction damage. (**Figure 3-79**).

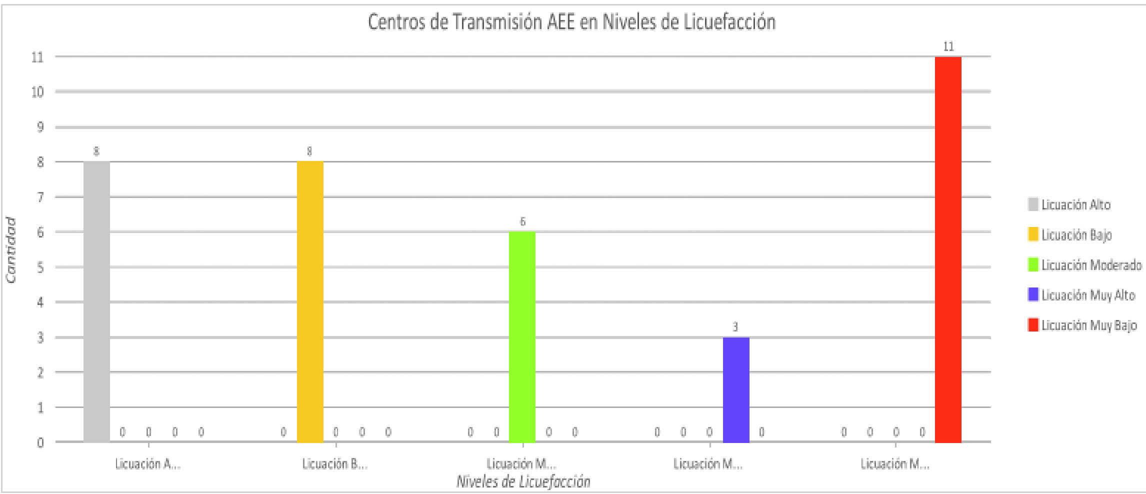


Figure 3-79. PREPA transmission centers in liquefaction levels.

The largest PREPA substations are found in Low liquefaction, with a total of one-hundred seven (107) substations. The next categories are Very Low liquefaction with one-hundred five (105) substations, followed by High Liquefaction with sixty-six (66) substations, Moderate liquefaction with forty-two (42) PREPA substations, and Very High liquefaction with eighteen (18) substations. Most substations are not at risk of liquefaction damage. (**Figure 3-80**).

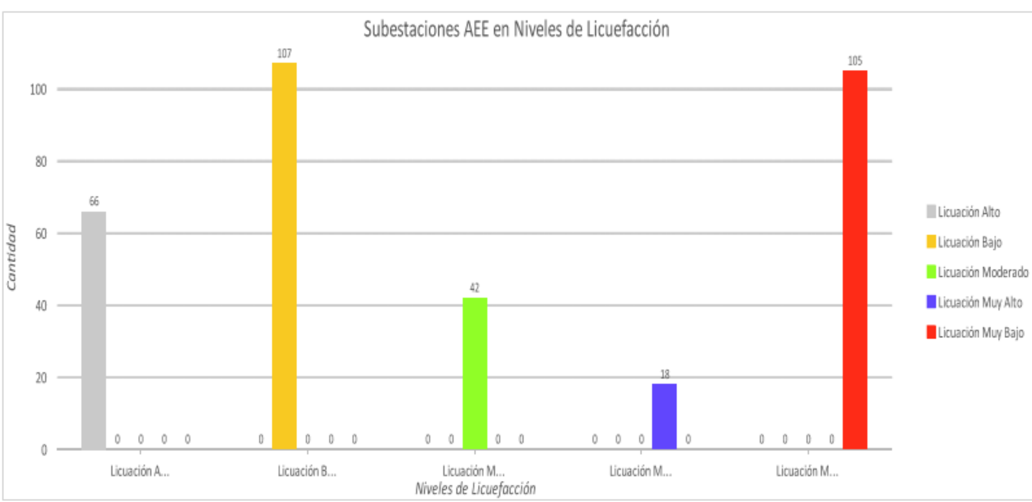


Figure 3-80. PREPA Electrical Substations in liquefaction levels

Regarding PREPA's plants, most of them are located on land classified as moderate liquefaction, with a total of four plants. There are three (3) plants in each category in the Low and Very High liquefaction category. There is one (1) plant in each category in the Very High and Low liquefaction category (**Figure 3-81**).

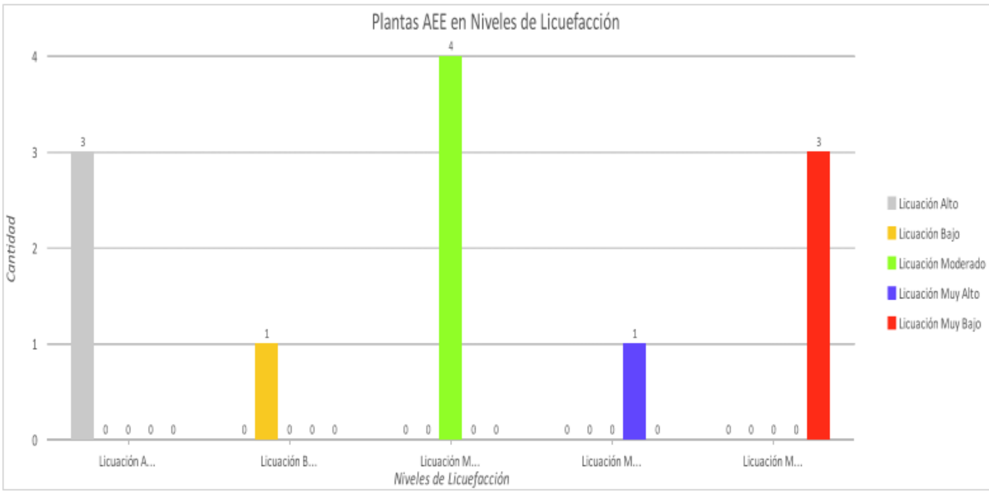


Figure 3-81. PREPA plants in liquefaction levels.

The largest number of shelters is found in areas categorized as very Low liquefaction with two-hundred and forty-nine (249) shelters. Then, in Low liquefaction, there are a total of one-hundred and twenty-two (122) shelters. In Moderate liquefaction, there are fifty-seven (57) shelters. There are thirty-eight (38) in High liquefaction, and in Very High liquefaction, there are eleven (11) shelters. (**Figure 3-82**).

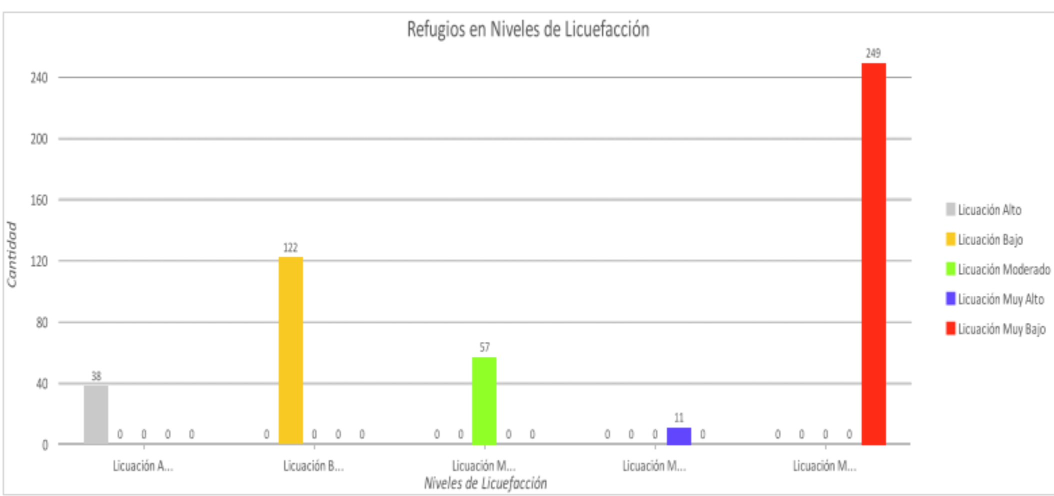


Figure 3-82. Shelters in liquefaction levels.

Seven hundred and ninety-seven (797) schools are in the Very Low liquefaction category and four-hundred and four (404) in the Low liquefaction category. On the other hand, the category of Very High liquefaction has the lowest number of schools, with forty-four (44) schools. There are two-hundred and twenty-one (221) in the Moderate liquefaction area and High liquefaction, two-hundred and seven (207) schools. Likely, many of these schools are already open, but according to the number of structures and their location they are not significantly exposed to liquefaction risk. Likewise, facilities in areas that pose a threat should be addressed to reduce the risk (**Figure 3-83**).

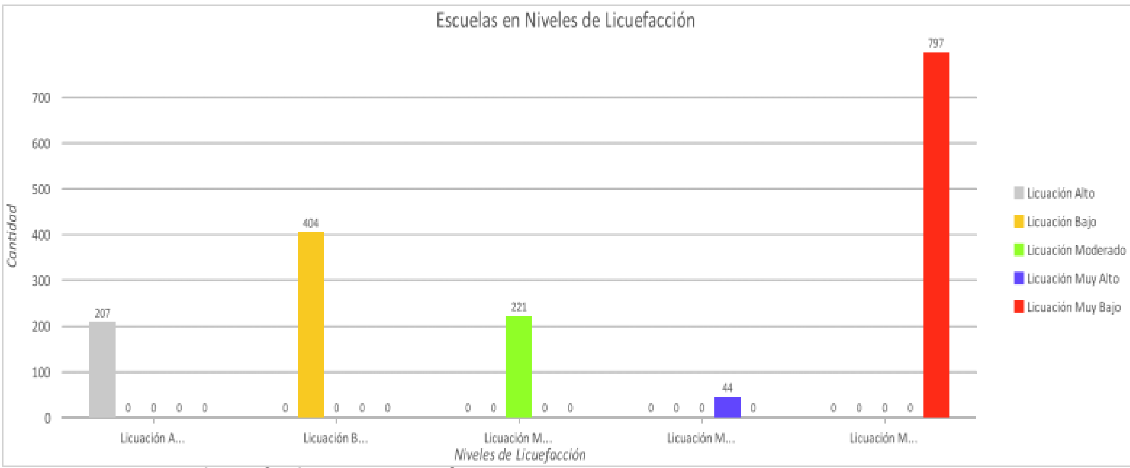


Figure 3-83. Number of schools in liquefaction levels.

The largest telecommunications facilities are located on Very Low liquefaction areas with forty-nine (49) antennas. The next category with the highest number of antennas is Low liquefaction with nine (9) antennas. In the Very High liquefaction category, there is only one (1) antenna. (**Figure. 3-84**).

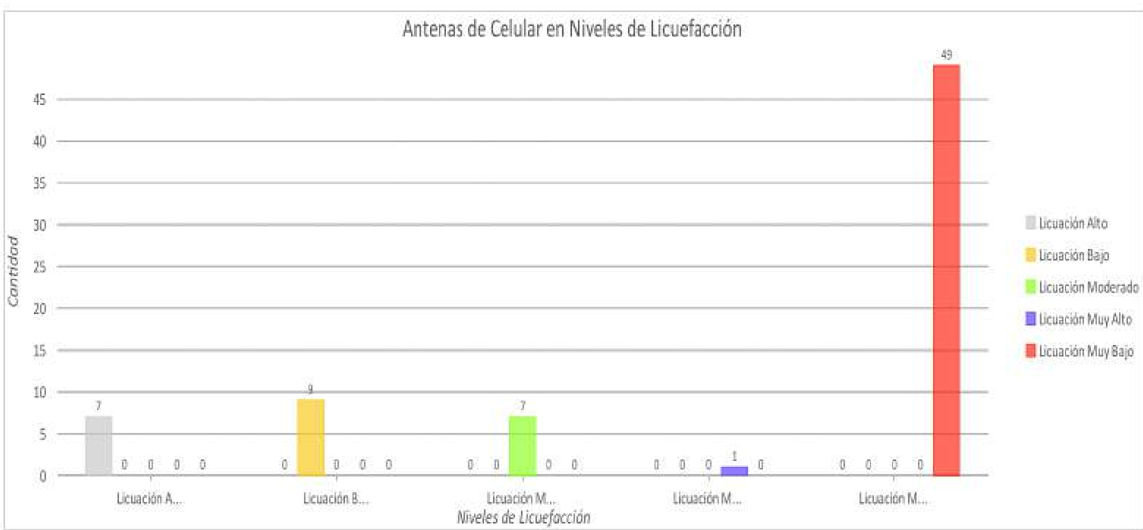


Figure 3-84. Telecommunication Cellular Antennas.

3.6.5. Potential Hazard: Fault and Fissures

Physical characteristic of the risk profile

For the physical characterization of the Puerto Rico faults' risk profile, this analysis integrated the concept of the maximum ground acceleration variable (or PGA) produced by the 6.5 earthquake event of January 7, 2020, specifically in the North Boquerón-Punta Montalva fault **(Figure 3-85).** This variable is a crucial measure in seismic engineering since it measures the accelerations suffered by the ground surface in an earthquake. It is divided into twelve (12) quantitative categories associated with the modified Mercalli scale's intensity. Depending on the recorded type of the event, both can be related to qualitative descriptions as to how the earthquake was perceived, ranging from "not felt" to "extreme" and the potential damage caused, ranging from "none" to "very intense" **(Table 3-68).**

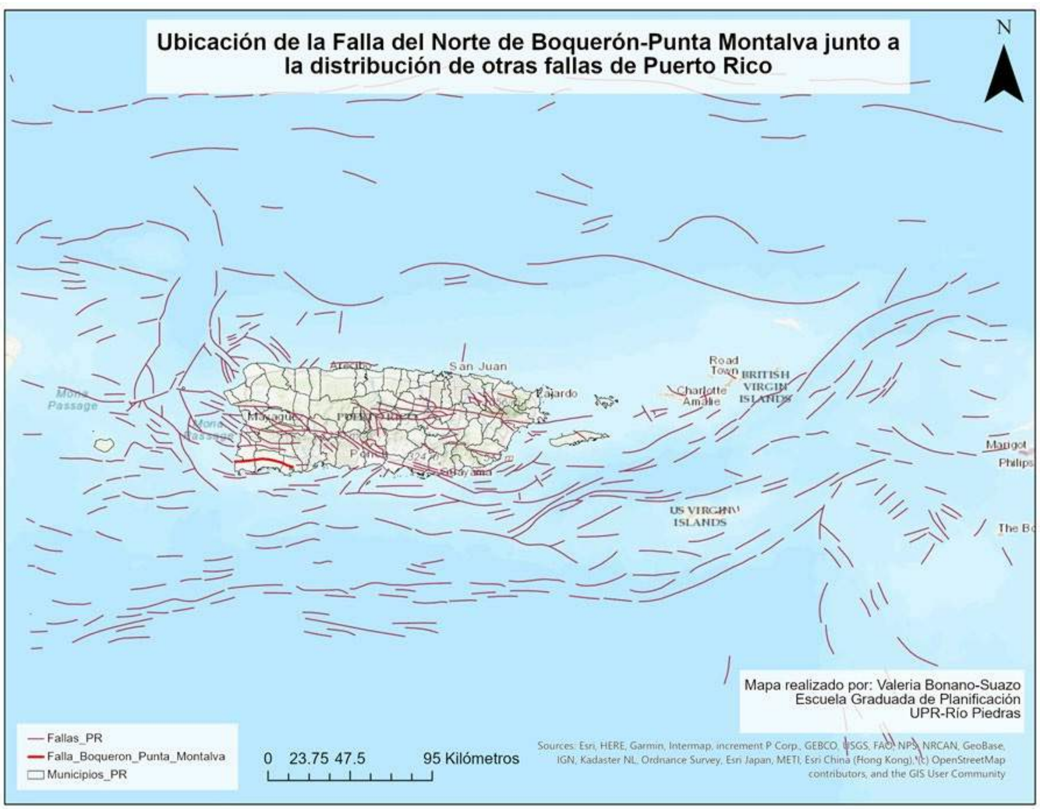


Figure 3-85. Location of the North Boquerón-Punta Montalva fault along with the distribution of other faults.

Table 3-68 Modified Mercalli Scale of intensity and the equivalent values in Peak Ground Acceleration (or PGA) and qualitative descriptions for each category (FEMA, 2001)

MMI	Aceleracion (%g) (PGA)	Percepción del movimiento sismico	Daño potencial causado
I	<0.17	Sin percepción	Nada
II	0.17-1.4	Débil	Nada
III	0.17-1.4	Débil	Nada
IV	1.4-3.9	leve	Nada
V	3.9-9.2	Moderado	Nada
VI	9.2-18	Fuerte	Muy Leve
VII	18-34	Muy fuerte	leve
VII	34-65	Severo	Moderado
IX	65-124	Violento	Moderado a fuerte
X	>124	Extremo	Fuerte
XI	>124	Extremo	Muy fuerte
XII	>124	Extremo	Muy fuerte

It should be noted that the spatial distribution of the intensity of the event that occurred on January 7, 2020, varied between intensity IV-VI with slight to strong acceleration in the municipalities that were distant from the south. Meanwhile, in the municipalities closer to the event's epicenter, it varied between intensity VII-VIII and very strong to severe acceleration (**Figure 3-86**). Indeed, the map shows how both the intensity and acceleration reached the entire island.

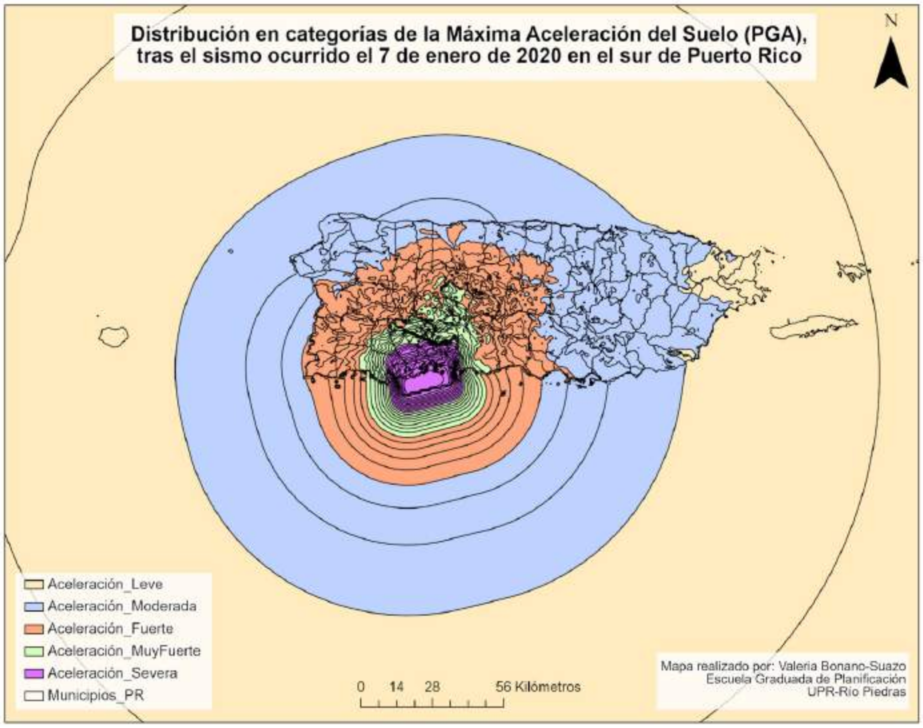


Figure 3-86. Distribution in categories of the maximum ground acceleration (PGA) after the earthquake occurred on January 7, 2020, in Southern PR.

Description of the Geodatabase

As part of the analysis of the faults and fissures of Puerto Rico, a geodatabase was created in ArcGIS-Pro, where data from the 2018 census, maximum ground acceleration (PGA) from the January 7, 2020 event, and 2015 infrastructure, among others, were grouped through the creation of seven datasets:

- Census Tract
- Infrastructure
- Original Data
- Faults
- PGA Categories
- PGA Demographics
- PGA Infrastructure

In the "PGA categories" dataset, categories were made based on risk characterization of the maximum ground acceleration variable (U.S. Geological Survey, 2020b). They ranged from "slight acceleration" to "severe acceleration."

Regarding the "Fallas_Puerto_Rico" dataset, the following faults were named, based on two feature classes previously created and cited in scientific articles, where they were highlighted **(Figure 13)** (French, 2004 & Styron et al., 2019). Specifically, the information that was collected in the attribute table was: the status of seismic activity, the possible magnitude of an earthquake, the type of landslide, among other pertinent details to know, of this risk. The faults considered were the following:

- Anegada
- Boquerón - Punta Montalva
- GNPR
- GSPR
- Mona
- Muertos
- Septentrional
- Sombrero
- PR Failures
- Trench PR

The dataset "Datos_Census_Track" included sociodemographic data for Puerto Rico at the Census Tract level (U.S. Census Bureau 2018). The variables considered were the following: number of disabled persons, females as homeowners, income, population under 16 years old, population over 65 years old, and total population. Finally, as for the dataset "Data_Infrastructures" we considered the relevant and indispensable infrastructures for the communities, such as water, electricity, roads, and telecommunications. Specifically, in this dataset, we can find water and sanitary lines, PREPA plants with substations, telecommunication antennas, transmission centers, roads, schools, and shelters.

For the following two sections, the "severe" acceleration category of the earthquake will be used as an example to represent all the population and infrastructure that was closest to the occurrence of the seismic event of January 7, 2020.

Social vulnerability based on risk[20]

To determine the population's exposure to the risk of faults and fissures, the scenario of the earthquake event that occurred on January 7, 2020, south of Puerto Rico, associated with the North Boquerón-Punta Montalva fault, is used. This scenario is used to define the population's exposure to this risk since no studies or models were identified that would present detailed scenarios on the seismic behavior of the (active) faults on the island. To evaluate the exposure of the population to this risk, six sociodemographic variables were selected, which are the most common indicators used in the literature to represent social vulnerability. These are: total population, population aged 65 years or older, population aging 16 years or younger, female homeowners, population with some disability, and households with a total income of less than $10,000 per year.

Based on the January 7, 2020 Magnitude 6.4 earthquake scenario, the municipalities most affected by the "severe" category of maximum ground acceleration caused by this event were Guánica, Guayanilla, Peñuelas, Ponce, Sabana Grande, and Yauco. All these municipalities had a total population of 32,230 exposed to severe acceleration, where according to data from the 2018 Community Survey:

7,263 (22%) of the population identifies with some disability.
6,766 (21%) of the population is 16 years old or younger.
5,708 (17%) of the population are 65 years of age or older.
3,334 (10%) households have an income of less than $10,000 per year.
2,418 (7.5%) households are headed by women.

Physical vulnerability based on risk[21]

To determine the physical exposure because of the event that occurred on January 7, 2020, South of Puerto Rico, specifically in the North Boqueron-Punta Montalva fault, the following critical infrastructure was selected: water lines, sanitary, pumping, roads, transmission centers, power generation plant, substations, telecommunication antennas, and shelters.

[20] Additional tables and maps in the appendices section.
[21] Additional tables in the Appendix section.

Table 3-69. Critical infrastructure exposed in the category of the maximum ground acceleration severe, from the average extent or shape length.PGA) and qualitative descriptions for each category (FEMA, 2001)

Name Infrastructure	Tremor accelera-tion	Average Shape Length (in meters)
PRASA - Waterline	Severa	219.64 (0.22 km)
PRASA - Sanitary	Severa	51.04 (0.051 km)
PRASA - Sanitary pumping	Severa	444.37 (0.444 km)
Roads	Severa	198.43 (0.198 km)
State Highways	Severa	1,095.69 (1,096 km)

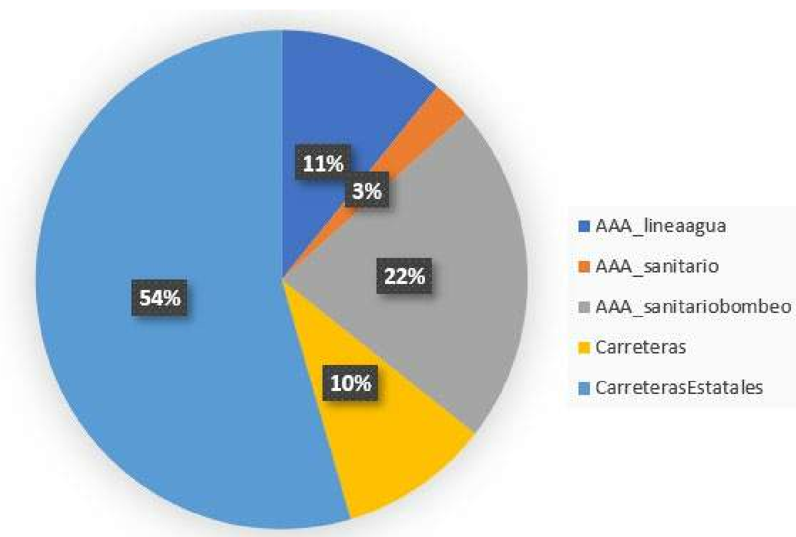


Figure 3-87. Percentage graph of water infrastructures exposed in the category of the maximum severe ground acceleration, from the average spread or shape length.

Figure 3-88 (below) shows the extent of state highways affected, starting with the "severe" category. On the other hand, of the other six infrastructures (in terms of quantity).

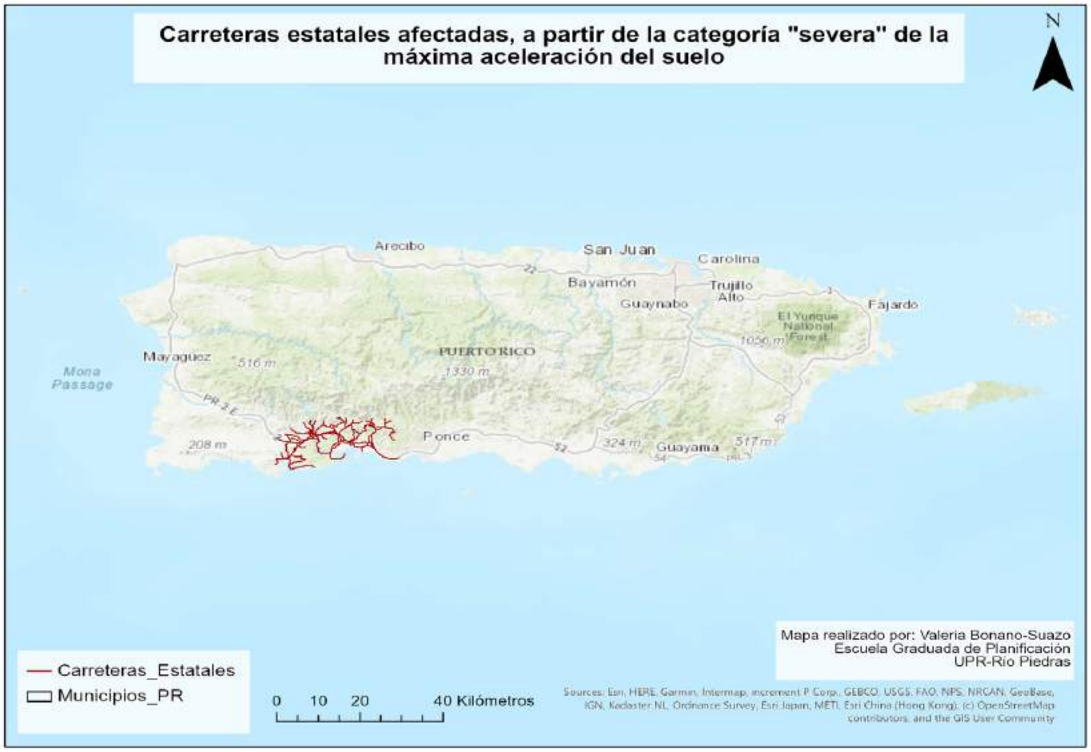


Figure 3-88. State highways affected, based on the "severe" category of maximum acceleration.of the soil.

The infrastructure most affected were schools, with 60 (66%), followed by shelters, with 17 (**Table 3-70 and Figure 3-89**).

Table 3-70. Accounting of exposed infrastructures in the category of maximum acceleration of severe soil.

Name Infrastructure (Schools and Shelters geodatabase are not up to date as of 2020)	Tremor acceleration	Exposed infrastructure
PREPA - Transmission centers	Severe	1
PREPA - Power Plants	Severe	
PREPA - Sub-Stations	Severe	
Telecommunication Antennas	Severe	1
Schools*.	Severe	
Shelters	Severe	

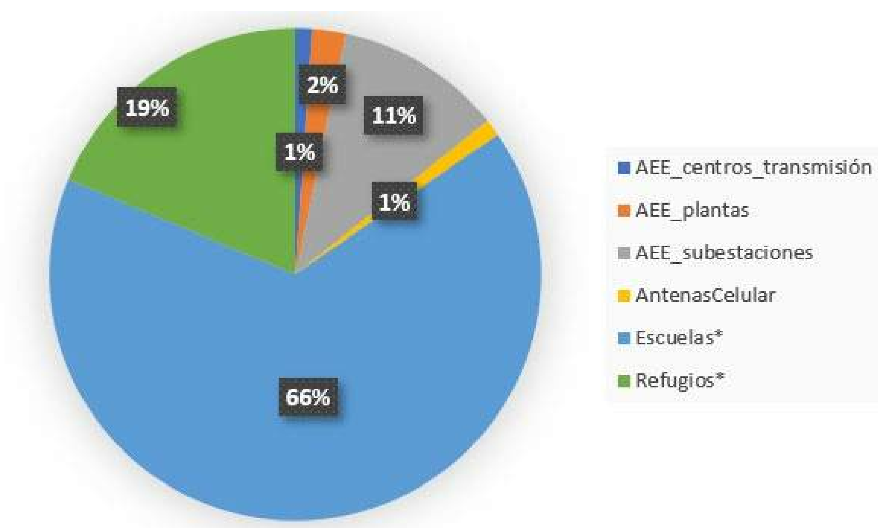


Figure 3-89. Critical infrastructure exposed in the category of maximum severe ground acceleration.

Figures 3-90 and 3-91 show the number of schools and shelters affected, starting with the "severe" category.

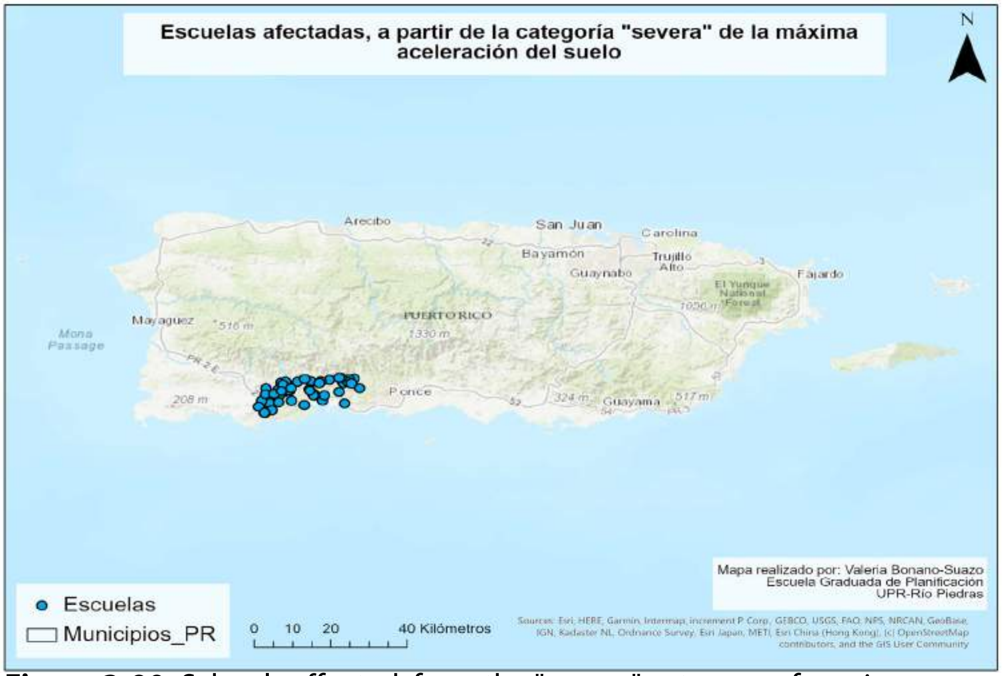


Figure 3-90. Schools affected, from the "severe" category of maximum ground acceleration.

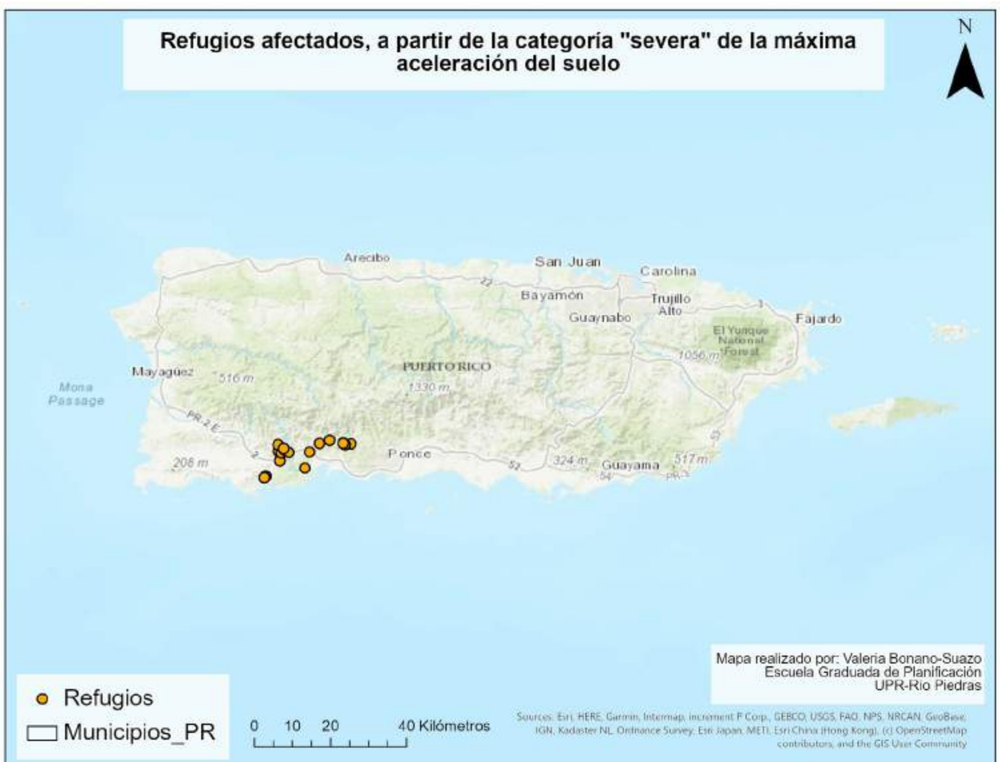


Figure 3-91. Affected refugees from the "severe" category of maximum acceleration of the soil.

3.6.6. Potential Hazard: Droughts

Drought events in Puerto Rico are monitored by the U.S. Drought Monitor (USDM), Department of Natural and Environmental Resources (DNER), U.S. Geological Survey (USGS), and Puerto Rico Climatic Change Council (PRCCC), among others. For this analysis, the types of drought to be evaluated will be Socioeconomic and environmental drought and meteorological drought.

According to the assessments conducted by the USDM, the DNER, the Puerto Rico Aqueduct and Sewer Authority (PRASA), and the Government of Puerto Rico (GPR), nine (9) drought events have been identified in Puerto Rico for the period from 1923 to 2020. The most extreme drought events on the Island are 1964-67, 1994-96, and 2014-16 (**Table 3-71**) – next page. For droughts between the period 1923 to 1957, there is limited information (Colón, 2009). These events have mostly affected the northern, eastern, and southeastern municipalities.

Table 3-71. Drought Events in Puerto Rico (1923-2020)

Year(s)	Amount of precipitation (mm/inch)	Description of the event	References
1923	51.63"	Not available.	Colón, 2009
1930	53.74"	Not available.	Colón, 2009
1947	53.10"	Not available.	Columbus 2009
N/A	52.65"	Not available.	Colón, 2009
1964-1967	43.2 (1967)	It took more than a year for the Carraízo reservoir to fill. The drought was the most intense in the eastern part of the Island.	PIRA, 2016
1973-1976	46.8 (1976)	It affected mainly the Northern and Eastern parts of the Island. It raised questions about future reservoir locations.	Colón, 2009
1994-1995	45.0 (1994)	Economic losses of more than $300M; $165M in agriculture. The drought was intense for the entire Island.	PIRA, 2016
2014-2016	50.98	First regional event analyzed by the USDM, after its foundation in 1999 and classified as Extreme Drought D3. The eastern interior and southeastern areas were the most affected.	Castro, 2019 USDM Quiñones, 2015
	To be determined	The Department of Agriculture allocated funds for the agricultural industry. The drought was moderate and more intense in the southern part of the Island.	PR Newspaper, 2020

In Puerto Rico, a trend of vulnerability to risk has been observed in the southeastern and southwestern areas. This may be due to a combination of less accumulation of rainwater and land use. In this area of the Island, there are significant amounts of land used for the agricultural industry. A study by the Puerto Rico Water Resources and Environment Research Institute determined that:

> *"The greatest demand for agricultural water occurs in the watersheds of the Southwestern and South-central regions of the Island. This is expected because these are mostly full regions where the large farms where much of the agricultural exploitation occurs are located. They are also the arid areas where irrigation systems have been established. In these areas, 97 percent of the agricultural water demand is produced by crops. The rest of the demand is by livestock enterprises; this contrasts with 70 percent of the water use by crops for the entire Island."*

Evaluation of the observed annual precipitation distribution shows that yearly precipitation in Puerto Rico varies from year to year. Precipitation totals have been near or above average since 1955, with only two periods experiencing well below average conditions. The dark horizontal line is the long-term (1955-2017) average of 61 inches per year (**Figure 3-92**). These values are averages from 11 long-term reporting stations in Puerto Rico.

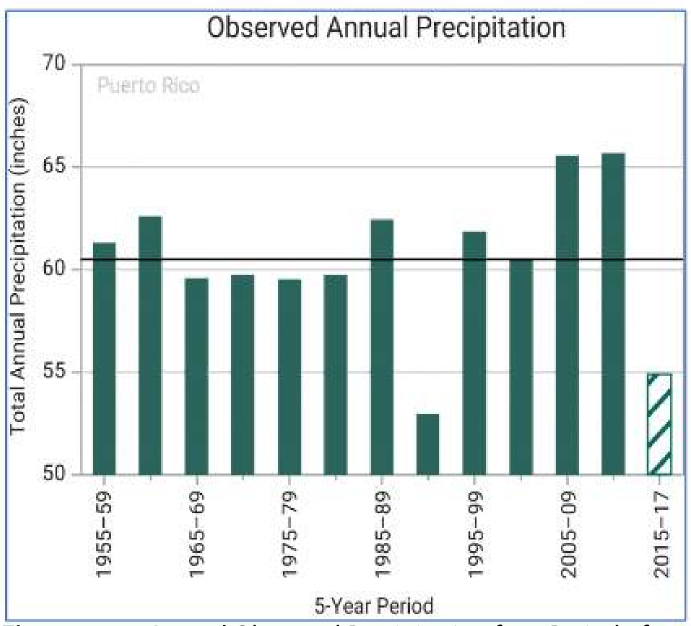


Figure 3-92: Annual Observed Precipitation for a Period of Five (5) years in Puerto Rico.

On the other hand, although there is no reduction in the average annual precipitation, a reduction in the areas with normal humidity levels is beginning to be observed (**Figure 3-93**).

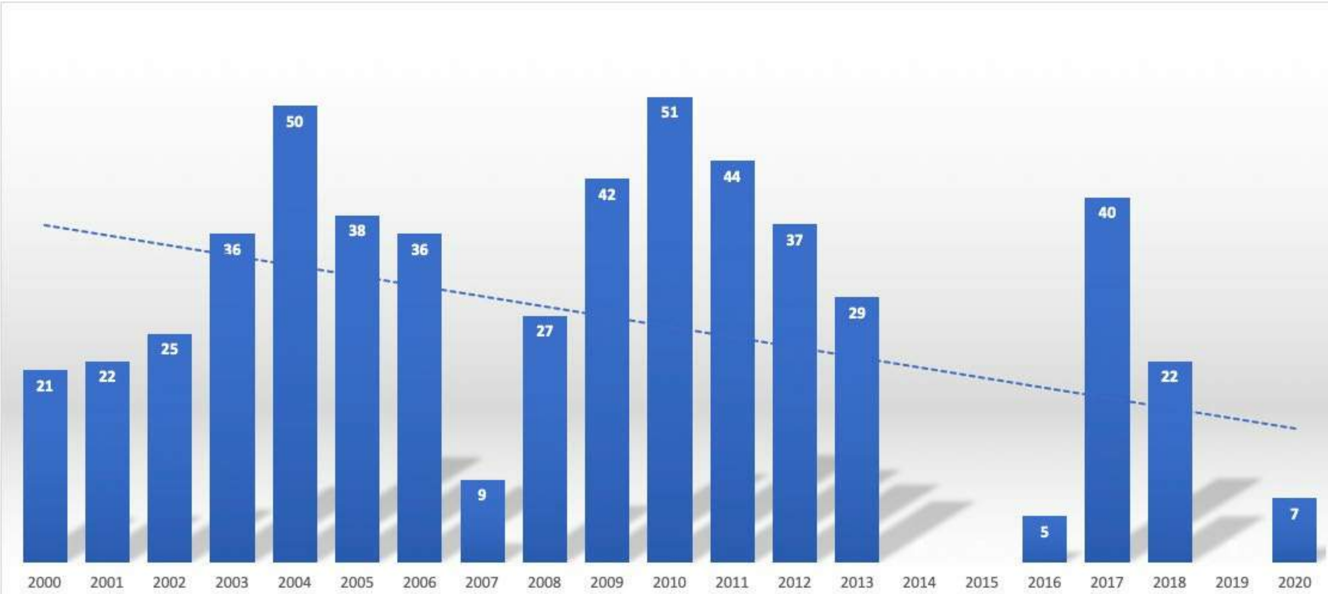


Figure 3-93: Weeks without dry weather or drought conditions, with statistical trend line.
Source: Avilés Vázquez, K. (2020).

Currently, the priority of drought risks is ranked ninth (9th) in the LHMPs. The priority, per emergency declarations, should rank fourth (4th) according to the 2016 PRSNHMP. Looking at the frequency of the last 20 years of events, drought remains in 4th place, after floods, storms, and landslides.

The economic impact of a drought is a factor for consideration in the priority levels. The PRSNHMP analysis incorporates the sum of the effects estimated for each risk in the LHMPs. The sum provided in the 2016 PRSNHMP estimates drought damages at $6M, which supports placing drought in low priority as a risk for Puerto Rico. Despite this amount, 1994-95, 2015-2016, and 2020 Economic Reports published by the PRPB reflect losses of $300M, $20M (agricultural sector only), and $3.2M (PRASA only) a result of the drought.

According to these economic reports of the most extreme events in recent years, the total losses for Puerto Rico indicate the need to update how values and losses are projected because of risk, particularly drought.

The risk of drought is intensifying on the Island due to a loss of reservoir capacity. The loss of capacity is caused by sedimentation, which is correlated with deforestation around the reservoirs. However, the general response historically has been to increase the capacity of the reservoirs. This can be seen in 1977 and 1999, in response to the 1996 drought. Also, it has been decided to connect other reservoirs through the North Coast Superaqueduct. The second pattern for addressing drought conditions is to rely on or activate water sources. According to the Comprehensive Water Resources Plan (PIRA, 2016), this presents a severe limitation: these are closed due to lack of maintenance or whose water source may not be available due to lack of aquifer recharge.

In addition to the direct impact of the drought, it is necessary to calculate the secondary effect of drought periods that include an increase in wildfires, and an increase in the impact of poor aquifer management, combined with the rise in sea level. After years of exploitation, the southern aquifers have suffered saline intrusion, exacerbating the effects of the drought on the area's economic activity (agriculture) and requiring operational changes.

The Island's precarious fiscal conditions presented another enormous challenge for the attention and management of the drought. The alternatives available to provide economic support in the face of the heavy losses in the various affected sectors (residential, commercial, institutional, agricultural, and ecological) are limited by the present discal situation that Puerto Rico is currently suffering, especially the central government. Another major challenge the government faced was attending to the start of classes in the public education system during August 2015 underwater rationing measures in the East's municipalities.

In Puerto Rico, drought is addressed after the fact because the drought plans do not provide for addressing a sustained category 4 and 5 deficits beyond adjusting what comes out of the reservoir to the incoming flow. The use of drought data from the past 30 years increases vulnerability to drought management because it does not incorporate expected changes. This deficiency manifested itself in the 2014-2016 drought management, which does not implement adjustments in time to reduce its impact.

Extreme drought events in Puerto Rico

The negative impact of drought is based on a combination of the frequency, severity, and spatial extent of the drought and how the population's activities may be affected by it (PEMPN, 2016). Historically, Puerto Rico has only two presidential drought declarations, for which information is scarce. These are Presidential Disaster Declaration No. 170 of May 26, 1964, and Presidential Disaster Declaration No. 3000 of August 29, 1974. Presidential disaster declaration No. 170 was due to extreme drought conditions and is estimated to have been the most severe drought ever to occur in Puerto Rico. The 1974 drought obtained a presidential declaration because of severe impacts, with the third-lowest level of precipitation to date. Its severity led to questions about the future location of reservoirs to supply the population.

Puerto Rico has experienced three significant drought periods that have not had a presidential emergency or disaster declaration. These are the drought events of 1994, 2015, and 2020.

- Drought 1994-1995: The 1994-95 drought began to be identified with a reduction in average rainfall since the second half of 1993. The drought covered 55% of the Island, with the peak in the summer of 1994 and a maximum rationing period of 40 hours. Reservoirs did not return to maintenance levels until the summer of 1995.
- Drought 2014-16: This drought covered more than 85 percent of the Island's area and necessitated a rationing plan with up to 48 hours without service.
- Drought 2020: This drought covered 35 percent of the Island and required a rationing plan of up to 24 hours.

How the percent of the Island affected by drought is expressed also varies according to the source. The simplest case we use for this analysis is the number of municipalities affected by the total number of municipalities in Puerto Rico.

Protocol for Drought Management in Puerto Rico

Following the events of 2015, the Puerto Rico Drought Management Protocol was created that equates drought levels with monitoring actions, responsibilities by agency, and four committees. According to the resources and experiences of each agency, these were assigned to the different committees. This protocol addresses two significant areas of work: (1) Executive Drought Management Committee and (2) Action Phases. The Executive Committee supports its decisions with recommendations from four components: (1) Action and Response Committee; (2) Reservoir Management Committee; (3) Communications Committee; (4) Science Committee **(Table 3-72).** The Drought Management Protocol should be reviewed and strengthened based on the experience and scientific and technical information available at the time for the attention and management of drought events in Puerto Rico.

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the experience and scientific and technical information available at the time for the attention and management of drought events in Puerto Rico.

Table 3-72: Drought Management Action Committees in Puerto Rico (Drought Plan, 2015).

Action and Response Committee	It coordinates and implements actions for drought management per executive decisions.
Reservoir Management Committee	It is responsible for ensuring the optimal use of the reservoirs in Puerto Rico during the drought and the necessary coordination.
Communications Committee	It is responsible for informing the public of drought occurrences and will formulate strategies to disseminate information to the public.
Scientific Committee	It provides technical and scientific advice to the Executive Drought Management Committee. Besides, it is responsible for reviewing, evaluating, and updating the Drought Management Protocol.

For the period covered by this Plan, legal mechanisms associated with the issue of drought in Puerto Rico were created for drought emergency water management, as shown in **Table 3-73**.

Table 3-73: Laws and Executive Orders associated with the drought issue in Puerto Rico (2016-2020).

Document	Date	Description
OE-2020-049	June 29, 2020	Executive Order of the Governor of Puerto Rico, Hon. Wanda Vázquez Garced to declare a state of emergency regarding the use of water due to drought and to establish an Interagency Action Plan based on the current protocol for drought management in PR.
Law 33-2019	May 22, 2019	Puerto Rico Climate Change Mitigation, Adaptation and Resilience Act.

Physical Characteristics of the Risk Profile

From the definition and theory of risk perspectives, it is imperative to observe the physical characteristics of the risk profile. This helps to deepen the analysis and study of drought risk. The extent and severity of drought can be monitored in various ways and usually depends on the impact of drought on a specific activity or phenomenon, operational definition.

Drought levels or categories

The USDM groups the data into five categories: D0- Atypically Dry, D1- Moderate Drought, D2- Severe Drought, D3- Extreme Drought, and D4- Exceptional Drought (2016 PRSHNMP), **(Table 3-74).** Although D0 is not a drought period, these atypically dry characteristics indicate areas entering or recovering from a drought period, which can better prepare us to prevent impacts to the population.

Table 3-74: Drought Categories.

Atypical Drought (D0)	A short-term period of drought is observed, which slows planting and crop growth. Some persistent water deficits are kept, and crop pastures are not fully recovered.
Moderate Drought (D1)	Some damage to crops and pastures is observed. Some water shortages develop, and voluntary water use restrictions are requested.
Severe Drought (D2)	Crop and pasture losses are documented, water use restrictions are imposed.
Extreme Drought (D3)	Significant crop and pasture losses are recorded. Widespread water restrictions or shortages are implemented.
Exceptional Drought (D4)	Exceptional and widespread crop and pasture losses are recorded. Water scarcity generates water emergencies.

The protocol establishes the phases of action for drought management and the main actors for each of the stages (**Table 3-75**). One of the main indicators of drought conditions is the USDM. The monitor summarizes climatological, hydrological, and soil moisture conditions and local effects and observations. The data is updated every seven (7) days to establish or designate the severity of the drought period. This index shows five categories to group drought conditions and defines their impacts.

Based on these categories, it is recommended to establish three phases of action in the event of a drought that reflect similarities with the classification of emergency warnings for tropical cyclonic events, which are already known and assimilated by Puerto Rico's population.

Table 3-75: Drought Action Phases.

Phases	Category Drought Monitor	Shares
Surveillance	D0; D1: Atypically dry conditions; moderate drought.	• Monitoring and surveillance of drought conditions. • Identify new decision-making tools for drought care andmanagement (e.g., early detection systems). • Activation of the Scientific Committee. • Activation of the Reservoir Management Committee. • Activation of the Communications Committee. • Recommendation to the Governor to declare a state of drought.
Drought Advisory	D1; D2: Moderate drought; severe drought.	• Activation of the Committees by the Executive-Committee • Weekly Work Plan for Drought Management Committees • Coordination of interagency efforts • Review of drought management actions by agency • Review of the drought component in the LHMPs. • Scientific Committee Meetings. • Implementation of immediate drought management actions (by agency) • Implementation of preventive measures to avoid • problems of stress and mortality of aquatic fauna in reservoirs and bodies of water.
Extreme Drought Warning	D3; D4: Extreme drought; exceptional drought	• Continue with actions and measures established in the Drought Warning phase. • Establishment of prolonged drinking water and irrigation rationing • Water franchise review and restrictions. • Identification of areas for constructing new water wells and/or reactivation of wells, assigning priority to human consumption. • Restrictions and review of NPDES permits in rivers and surface water bodies

		• Attention to complaints and review of compliance with price freezes in stores. • Strict review of compliance with water quality-standards for imported waters. • Activation of the Puerto Rico Police for surveillance of PRASA's water production infrastructure. • Activation of water distribution centers by municipality. • Implementation of measures to address animal-mortality in the livestock industry. • Implementation of measures to address aquaticfauna mortality in reservoirs and bodies of water. • Consideration of National Guard activation • Emergency Declaration Evaluation.
Culmination of State of Drought	This phase is activated once the Drought Monitor has eliminated the classification of moderate (D2), severe (D3) and extreme (D4) drought in its entirety for all of Puerto Rico and remains out of this condition for two consecutive weeks.	• Review of drought conditions • End of drought declaration • Report on socioeconomic impacts of drought.

According to the PIRA, drought patterns begin to be registered in April and May without necessarily being reflected in the reservoirs. However, the decline in quantity or lack of precipitation in these initial months of the year means that the reservoirs are not in optimal conditions to meet the demand and period of low rainfall (except for storms) in the summer. For this reason, the months of July and August of the years 2016-2020 were selected, which reflect whether drought conditions have been sustained entering hotter months and higher demand. The distribution of atypically dry or drought areas observed on the Island from 2016 to 2019 maintains the trend of risk exposure for the southern, southeastern, and southwestern towns (**Figure 3-94**).

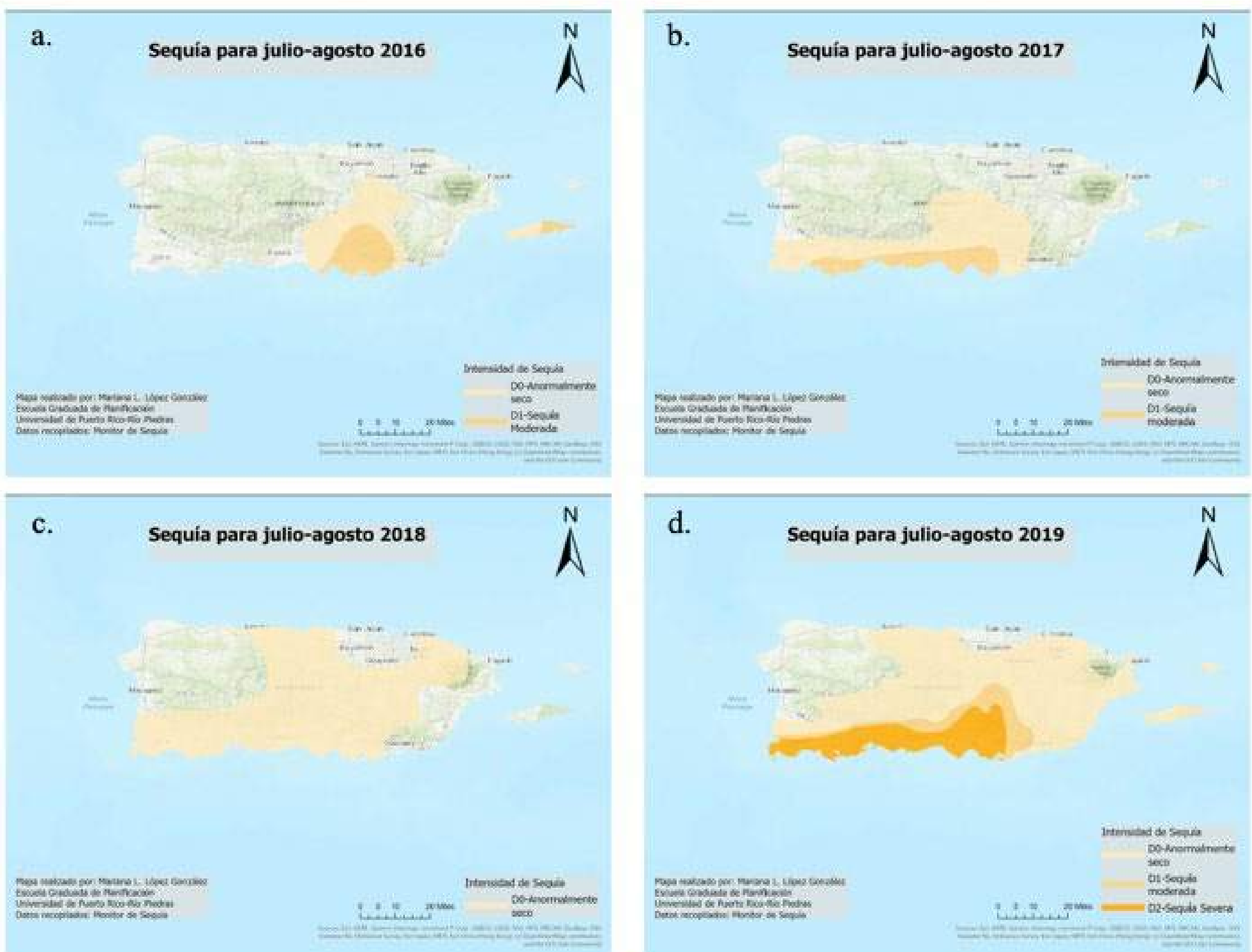

Figure 3-94: Drought distribution 2016-2019; Source: López González, M. (2020)

These areas coincide with a change in vegetation that is more prone to fire, so the footprint of areas prone to dry periods coincides with wildfires' secondary risk.

CDBG-MIT Action Plan managed the Drought Monitor website and related data and provides the map and data to NOAA, the Department of Agriculture, and other agencies. The polygons generated by the Drought Monitor represent areas that have experienced drought conditions from 2000 through 2019. experienced drought conditions from 2000 through 2019 throughout Puerto Rico. Rico. In each hexagonal grid, the number of instances (weeks) of drought were entered, which were categorized into the following categories of drought, which were categorized using an equal interval ranking.

The risk of drought is most prevalent in the south-central and central areas of the island and radiates along the southern coast and into the central and north-central regions of the island. Eighty-three percent (83%) of the municipality of Salinas falls into the of Salinas falls within the highest frequency of drought category and more than sixty-three percent (63%) of the municipality of Salinas falls within the highest frequency of drought category. sixty-three percent (63%) of all high drought areas on the island are also located in this area. are also located in that area. Several adjacent municipalities have most (if not all) of their territory within the medium-high drought category and when classifying each municipality in all risk categories by area, one can easily see the most affected areas in terms of drought. the most affected areas in terms of drought.[26]

Social Vulnerability to Drought Risk.

During the analysis period of the last five (5) years (2016-2020), 2020 reflected drought conditions for Puerto Rico. 2020 is analyzed individually, also focusing on July and August, for which the risk impact footprint was identified, and the affected population and infrastructure were quantified.

The municipalities with the most significant direct exposure to risk were identified (**Table 3-76**) considering the atypically dry conditions and drought conditions that occurred in 2020, primarily from D1 and D2. This analysis does not consider municipalities that may rely on water supply outside of the dry conditions' footprint**. Figure 3-95** illustrates the municipalities with the most significant exposure to drought risk, mostly located in the South, Southeast, and Northeast of the Island.

[26] CDBG-MIT Action Plan, p. 479

Table 3-76: Municipalities with greater exposure

Aguas Buenas	Aibonito		Arroyo
Cabo Rojo	Caguas		Canóvanas
Carolina	Cayey		Cidra
Coamo	Guayama		Guaynabo
Gurabo	Juana Diaz		Juncos
Lajas	Las Piedras		Loíza
Patillas	Ponce		Rio Grande
Salinas	San Juan		San Lorenzo
Santa Isabel	Trujillo Alto		

Figure 3-95: Municipalities with greater exposure to drought risk, Source: López González, M. (2020)

Population at Risk.

Droughts in Puerto Rico have a peculiarity in that they impact the geographic area where they are recorded and have the potential to impact distant areas that are nourished by the location of the impacted water sources. Similarly, in the case of drought, the level of exposure of the population is unequal. For this analysis, exposure is classified into direct exposure, indirect exposure, and full exposure.

Direct exposure is the population in the geographic area declared drought; indirect exposure is the population that draws from water sources. Full exposure is the people living in an area directly impacted by drought whose livelihoods are wholly affected by the drought. This analysis presents the population strictly at the direct risk exposure level due to lack of data. Still, the Planning Steering Committee recommends following up and analyzing the indirect and full exposure levels to incorporate in the next update of this Plan.

Total Population: Of the population exposed to drought (Figure 3-96), we found:

- 35% of the population - 252,772 people exposed to abnormally dry seasons (D0).
- 40% of the population - 295,612 people exposed to moderate drought seasons (D1).
- 25% of the population - 182,405 people exposed to severe drought seasons (D2).

Figure 3-96: Affected Population - Extreme Event 2020

People over 65 years of age: Of the people over 65 years of age exposed to drought (Figure 3-97):

- 37% of the population is older than 65 years for areas affected by abnormally dry seasons (D0).
- 40% of the population is older than 65 years for areas affected by moderate drought seasons (D1).
- 23% of the population is older than 65 years for areas affected by severe drought seasons (D2).

Figure 3-97: Population over 65 years of age affected by drought risk 2020

People under 16 years of age: Of the people under 16 years of age exposed to drought (Figure 3-98):

- Thirty-six percent of the population is under 16 years of age for areas affected by abnormally dry seasons (D0).
- Forty percent of the population is under 16 years of age for areas affected by moderate drought seasons (D1).
- Twenty-four percent of the population is under 16 years of age for areas affected by severe drought seasons (D2).

Figure 3-98: Population under 16 years of age affected by drought risk 2020.

People with an annual income of less than $10,000: Of those with a yearly income of less than $10,000, exposed to drought (Figure 3-99):

- 37% of the population has an annual income of less than $10,000 for areas affected by abnormally dry seasons (D0).
- 41% of the population has an annual income of less than $10,000 for areas affected by moderate drought seasons (D1).
- 22% of the population has an annual income of less than $10,000 for areas affected by severe drought seasons (D2).

Figure 3-99: Income less than $10,000 affected by drought risk 2020.

People with disabilities: Of the people with some type of disability and exposed to drought (Figure 3- 100):

- Thirty-three percent of the population suffers some type of disability for areas affected by abnormally dry seasons (D0).
- Thirty-four percent of the population suffers from some type of disability for areas affected by moderate drought seasons (D1).
- Thirty-three percent of the population suffers from some type of disability for areas affected by severe drought seasons (D2).

Figure 3-100. Disabled population affected by drought 2020

Female heads of household: Of the female heads of household exposed to drought (Figure 3-101):

- Thirty-two percent of the population in areas affected by abnormally dry seasons (D0) are female heads of household.
- Forty-six percent of the population in areas affected by moderate drought (D1) are female heads of household.
- Twenty-two percent of the population in areas affected by severe drought (D2) are female heads of household.

Figure 3-101: Female Heads of households affected by drought risk 2020.

Physical and Critical Infrastructure Vulnerability

Infrastructure analysis is an essential step because the presence and condition of infrastructure can precipitate drought, exacerbate drought conditions, and impact the population's quality of life. In the case of water infrastructure, narrower water lines, older material, or PVC, can be directly affected by drought and prevent water from reaching rationed areas during brief recharge windows.

Power generation substations sometimes depend on water availability to cool their boilers, and, in turn, water distribution depends on their operation to guarantee distribution to the population. Shelters cease to perform their essential function when they do not have the necessary resources, as evidenced by the shelters' condition without drinking water after Maria. Likewise, the school semester can be affected by the system's lack of capacity to handle hundreds of children in one place. Below, we describe each of these infrastructures directly impacted by the drought, recognizing that the indirect or full effect is not reflected in this analysis.

Water Lines: Of the water lines affected by the drought, the following was found (Figure 3-102):

- 34% of water lines are involved in areas affected by abnormally dry seasons (D0).
- 31% of water lines are affected in areas affected by moderate drought seasons (D1).
- 35% of water lines are affected in areas affected by severe drought seasons (D2).

Figure 3-102: Average Water Lines Affected by Drought 2020.

PRASA's sanitary facilities: Of PRASA's sanitary systems affected by the drought (Figure 3-103):

- 33% of PRASA's sanitary facilities are involved in areas affected by abnormally dry seasons (D0).
- 33% of PRASA's sanitary facilities are affected in areas affected by moderate drought seasons (D1).
- 34% of PRASA's sanitary facilities are affected in areas affected by severe drought seasons (D2).

Figure 3-103: Average PRASA Sanitation affected by the drought 2020.

Sanitary Pumps: The following was found in the pump toilet affected by the drought (Figure 3-104):

- 56% of PRASA's sanitary facilities are affected in areas affected by abnormally dry seasons (D0).
- 34% of PRASA's sanitary facilities are affected in areas affected by moderate drought seasons (D1).
- 10% of PRASA's sanitary facilities are affected in areas affected by severe drought seasons (D2).

Figure 3-104 Sanitary pumps affected by drought 2020.

PREPA substations: Of the PREPA substations affected by the drought (Figure 3-105):

- 41% of PREPA's substations are affected in areas affected by abnormally dry seasons (D0).
- 36% of PREPA's substations are affected in areas affected by moderate drought seasons (D1).
- 23% of PREPA substations are affected in areas affected by severe drought seasons (D2).

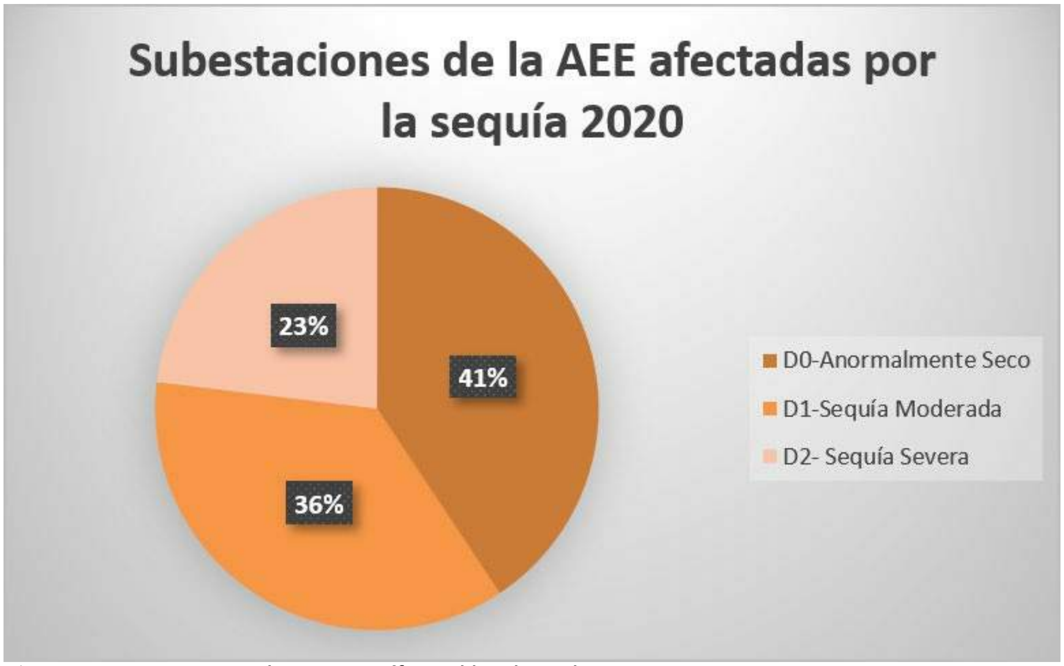

Figure 3-105: PREPA substations affected by drought 2020.

PREPA transmission center: Of the PREPA transmission centers affected by the drought (Figure 3-106):

- 39% of PREPA transmission centers are affected in areas affected by abnormally dry seasons (D0).
- 39% of PREPA transmission centers are affected in areas affected by moderate drought seasons (D1).
- 22% of PREPA transmission centers are affected in areas affected by severe drought seasons (D2).

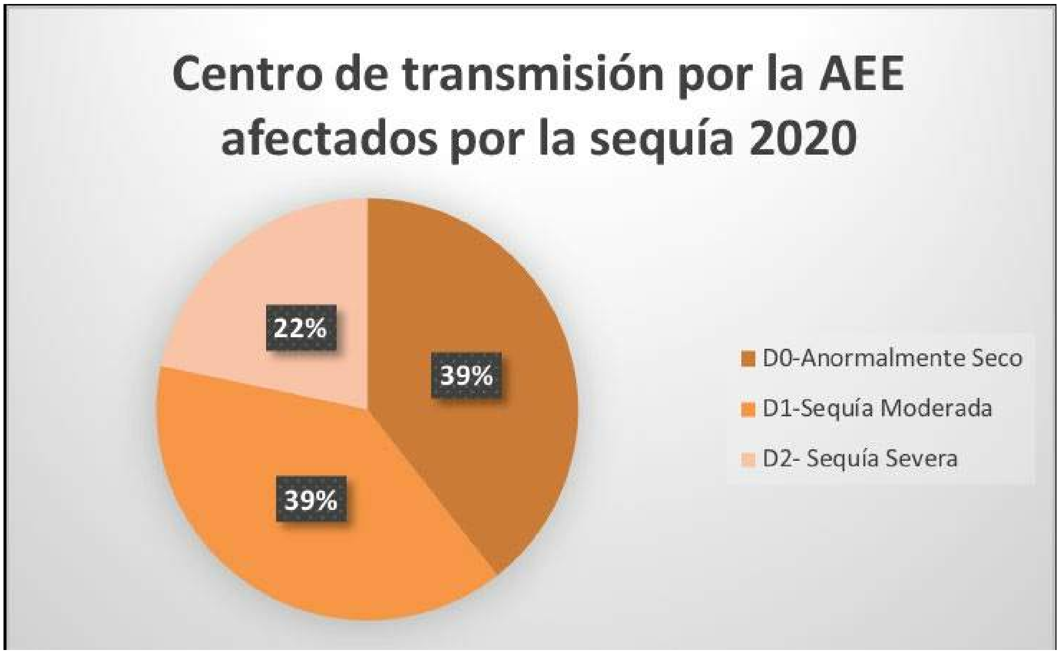

Figure 3-106: ESA transmission center affected by drought 2020.

Shelters: Of the shelters affected by the drought, (Figure 3-107):

- 35% of the refugees are affected in areas affected by abnormally dry seasons (D0).
- 42% of the refugees are affected in areas affected by moderate drought seasons (D1).
- 23% of the refugees are affected in areas affected by severe drought seasons (D2).

Figure 3-107: Refuges affected by drought risk 2020.

Schools: Of the schools affected by the drought (Figure 3-108):

- 34% of schools are affected in areas affected by abnormally dry seasons (D0).
- 43% of schools are affected in areas affected by moderate drought seasons (D1).
- 23% of schools are affected in areas affected by severe drought seasons (D2).

Figure 3-108: Schools affected by drought risk 2020.

3.7. Vulnerability Assesment of Critical Government Facilities

The analysis of government critical facilities that are vulnerable to natural hazards is very important, as they represent the state's ability to adequately respond to emergencies and maintain essential services required by citizens. the current guides and regulations of State Mitigation Plans establish to include an assessment of the vulnerability of critical facilities under the jurisdiction of the State Government   Many of these facilities can be critical to emergency operations, important government functions, housing vulnerable populations or provide continuity of important community services. Like 2016 PRSNHMP, this update defines a total of 21 types of critical facilities classified under two broad categories according to their service.

The categories and types of critical facilities are Category E - Emergency Response and Category I - Infrastructure.

Category E – Emergency Response

- E.1 Shelters (includes public and private, and other private)
- E.2 Regional Offices with Emergency Operations Centers of PREMB
- E.3 Police Stations

- E.4 Fire Stations
- E.5 Hospitals

Category I – Infrastructure

- I.1 Water Filtration Plants – PREPA
- I.2 Wastewater Treatment Plants – PRASA
- I.3 Potable Water Tanks– PRASA
- I.4 Pumping Stations– PRASA
- I.5 Dams– PRASA
- I.6 Hydrants– PRASA
- I.7 Wells– PRASA
- I.8 Airports, Ports and Heliports – PRPA
- I.9 Electric Power Substations Eléctrica – PREPA
- I.10 Bridges – DTPW
- I.11 AM Radio Antennas
- 1.12 FM Radio Antennas
- I.13 Radio Antenna Micro-Wave
- I.14 TV Digital Antennas
- I.15 Communication Towers - PRTB
- I.16 Gas Stations
-

The PRPB and the LHMPs mainly provided the sources of information for the data corresponding to critical facilities. In turn, they collect information from other agencies such as PRASA, PREPA, and DTOP, among others. The limitations identified in the 2016 PRSNHMP regarding the databases collected, which include: lack of detailed or descriptive facility information, incomplete inventory of some facilities, and inaccuracy in location, remained the same. On the other hand, not all critical buildings or facilities are incorporated in the inventories because coordinate data in electronic format or additional information was not provided when the inventories were completed. However, it is important to note that, although the 2016 PRSNHMP had more complete databases than those available for the 2011 PRSNHMP, these data were not accessible for incorporation into this update, which meant that the analysis was limited to the following critical infrastructure: sanitation and pumping, electrical substations and transmission centers, primary and secondary roads, shelters, schools, and telecommunication antennas.

It is important to clarify that the georeferencing data were taken from the 2018 Islandwide Risk Assessment used for local mitigation plans and data collected by the UPR Graduate School of Planning. In some cases, they may reflect geopositioning errors that could not be corrected as part of the 2021 PRSNHMP. The location's vulnerability ranges were obtained from the six (6) hazards evaluated: Flooding, Landslides, Extreme Winds, Earthquakes; Liquefaction, and Drought. Therefore, due to limited resources, data, and time to perform this

update, it is recommended that the next update establishes the individual and composite vulnerability rankings for State Critical Facilities as a product of the vulnerability analysis performed for the categories of critical facilities assessed.

Updating and vulnerability assessment of critical facilities was one of the activities proposed during the 2016 PRSNHMP period. Combined efforts among various government agencies and other specialized organizations will allow for more comprehensive and complete databases.

Critical Facilities Inventory.

The following is a summary of the inventory of critical facilities on the Island for which natural hazard vulnerability assessments were conducted. A complete list will be included in the next update when comprehensive assessment will be developed.

Table. 3-77. Summary of Inventory of Critical State Facilities.

Document	Description
Category E: Emergency Management	
E.1 Shelters (includes public and private, and other private)	247
E.2 Regional Offices with Emergency Operations Centers of PREMB	10
E.3 Police Stations	180
E.4 Fire Stations	46
E.5 Hospitals / Health Centers	119
Category I: Infraestructure	
I.1 Water Filtration Plants – PRASA	140
I.2 Wastewater Treatment Plants – PRASA	59
I.3 Potable Water Tanks– PRASA	2,168
I.4 Pumping Stations– PRASA	1,481
I.5 Dams– PRASA/PREPA	50
I.6 Hydrants– PRASA	178
I.7 Wells– PRASA	514
I.8 Airports, Ports and Heliports - PRPA	59
I.9 Electric Power Substations – PREPA	357
I.10 Bridges – DTPW	2,271
I.11 AM Radio Antennas	79
I.12 FM Radio Antennas	93
I.13 Micro-Wave Radio Antenna	1,749
I.14 TV Digital Antennas	29
I.15 Communication Towers	986
I.16 Gas Stations	1,691

Since 2000 the Puerto Rico Dam Safety Unit have being performing dam safety analysis and building a Risk Based profile for the most important dams in the Island. The methodology used by the dam safety unit is the same as the one used by the Bureau of Reclamation (Dam Safety Protection Guidelines). With the information gathered, the Dam Safety Unit prepared a chart of the Annualized Failure Probability vs. Estimated Life Loss with the risk driver in each dam safety risk assessment.

As stated before, Puerto Rico has 3,425 square miles there are 37 dams that are classified as high risk due to the people that may be affected in case of a dam breach. These dams provide water for human consumption, irrigation and power generation. Other dams are just for the purpose of inundation control. The state has the responsibility of protecting the life and property of the residents that reside downstream these water reservoirs. Any water impoundment represents risks. These risks must be identified and monitored. It is the purpose of the Dam Safety State Program to monitor the dam's performance in order to preserve the life and property of the residents downstream.

Prioritization of CDBG-MIT Funds in Vulnerable Structures.

With less funds available than the mitigation needs submitted by stakeholders, prioritization was fundamental for Puerto Rico's use of CDBG-MIT funds. As recommended in the Federal Register Vol. 84, No. 169 (August 30, 2019), 84 FR 45838, PRDOH incorporated the FEMA Community Lifelines into the Action Plan's assessments and design of the programs. Based on extensive analysis, critical and secondary lifelines and sectors were identified by PRDOH. Critical lifelines are 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, Food, Water, and Shelter.

All projects to be selected for funding by the CDBG-MIT program must mitigate risk. This is defined by HUD at 84 FR 45838, 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." Various of the CDGB-MIT Programs that will fund infrastructure, are written to strengthen or improve critical lifeline infrastructure. The CDBG-MIT 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, Community and Regional Investment, Lifeline Stability and Strengthening, and Alignment of Capital Investments. Stakeholder input, as well as knowledge gained from developing the risk analysis and mitigation needs assessment, were fundamental on the determination of the distribution of funding through nine (9) programs.

Due to limited resources, data, and time to perform this update, it is recommended that the next update establishes the individual and composite vulnerability rankings for State critical facilities as a product of the vulnerability analysis performed for the categories of critical facilities assessed.

This update recommends that in the future, the Interagency Mitigation Committee (with the assistance of the State agencies) will be responsible for the specific assessment through field inspection using an assessment technique as per the revision of the field inspection forms used in the 2016 PRSNHMP process. (See **Appendix 3-1**, Guide for the Vulnerability Assessment of Public Structures and Facilities). The concerned State Agencies should use the forms for field inspections to perform structural inspections of critical facilities. The methodology that would be used for the evaluation and estimation of potential losses should include the following steps:

- Selection of the categories of critical facilities to be included in the analysis.
- Location of the critical facility information in a geographic information base.
- Overlaying the information layer of the composite natural hazard map with that of the critical facilities' location.
- Account for critical facilities that are in high hazard areas and identify them by facility type.
- Estimate the average amount of loss that each type of facility could have.
- Apply the average estimate of potential losses by facility type to the analysis of facilities exposed to high hazard levels.
- Calculation of the potential loss by critical facility type.

3.8 Estimated Potential Losses Identified In Local Hazard Mitigation Plans

As part of integrating local mitigation plans, estimates of potential losses associated with the risks evaluated in this update were identified. Variations in the methodologies used for estimating potential losses in the local mitigation plans have resulted in limitations in their use and interpretation. However, the losses estimated in the local plans can be used as general indicators of the potential economic impacts that municipalities could receive from the identified hazards' impact.

The potential loss data included in this section were obtained from the local mitigation plans. The potential loss information consists of a sample of sixty-two (62) municipalities. **Appendix 3-3** have the estimated potential losses from the identified hazards in the evaluated LHMPs.

The result of the analysis of the potential cost estimate analysis of the hazards identified in the LHMPs evaluated in this update could represent a monetary loss to the country amounting to $30.6 billion for the six (6) hazards. This would represent an average potential loss per municipality of $493.2 million (based on data from 62 LHMP). The total estimated potential losses for the hazards identified in the LHMPs are presented below:

Table 3-73: Laws and Executive Orders associated with the drought issue in Puerto Rico (2016-2020).

RISK/HAZARD	AVERAGE*
Flooding	$11,391,227,586
Landslides	$10,668,925,41
Extreme Winds	$2,694,120,759
Earthquakes	$31,220,000
Geological Faults and Fissures	$5,761,845,226
Droughts	$30,717,979
TOTAL	$30,578,056,968

*To obtain the average per risk, the number of municipalities that reported for that risk was taken into consideration. For the total average, the total estimate of the 62 municipalities for which data was obtained was taken into consideration. **See Appendix 3-2.**

Repetitive Loss and Severe Repetitive Loss Estimates.

The Repetitive Loss (RL) and Severe Repetitive Loss (SRL) program is authorized by the federal Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004. This program was created for the purpose of reducing or eliminating long-term flood risks to structures that have experienced severe repetitive losses and are insured under the National Flood Insurance Program (NFIP).

Under the Program, a repetitive loss is defined as a residential property that is covered under NFIP insurance and that: 1) has had at least four NFIP insurance claim payments (including the structure and contents) of more than $5,000 each, and the cumulative amount of those claims exceeds a total of $20,000, or 2) has had two claim payments (payments for the structure only) whose cumulative value of the claims exceeds the market value of the structure.

To update the information submitted in the 2016 PRSNHMP as required by FEMA, the State Mitigation Plan should present a summary of the repetitive losses by municipalities being incorporated into the LHMPs as data becomes available. To update the information presented in the 2016 PRSNHMP and validate it with the LHMPs, it is necessary to validate the information with the NFIP data held by the GPR and that, due to limitations of technical resources and time required for this update, such analysis was not completed. To this effect, it is hereby established that all the information will be incorporated in the next update of this Plan.

3.9.Recommendations and courses of actions to reduce exposure and vulnerabilty to risk

This section presents a series of mitigation recommendations to reduce vulnerability and prevent the population from exploding over this identified risk:

To identify recommendations and courses of action to reduce exposure and vulnerability to the flooding risk, it is essential to consider local characteristics such as behavioral habits relevant to the communities, soil type, housing construction methods, poverty levels, existing social, political, and institutional organization, and cultural and ideological attitudes.

- Municipalities and other government agencies are limited in disseminating educational information on the flood risk affecting communities. It is necessary to provide educational workshops and/or create working groups to provide tools and knowledge to the communities to identify and interpret their flood risk zone.
- Among other recommendations for community education, the emphasis is placed on installing signs to inform and manage the community's perception of flood risk.
- It is recommended that guides be created that include information on the management of flood-prone areas and current public policy. A serviced office should be established to provide information to the community on the area's topography and alternatives for construction in flood zones.
- The elevation of housing in flood zones is encouraged as an adaptation measure.
- Promote flood control interventions, consisting of green infrastructure surrounding the communities and including the installation of retention ponds.
- In cases where adaptation and protection intervention are not feasible to control flooding, evaluate the intervention of planned relocation of houses located in high-risk areas. This intervention must be with community members' participation from the beginning of the planning of the intervention.
- Conduct courses of action to visualize evacuation routes in high-risk areas. It is understood that many of the communities exposed to risk do not have alternate evacuation routes. It is imperative to evaluate and provide a second alternate route to residents in a flood risk event.
- Conduct structural studies of bridges located in watersheds and make appropriate repairs.
- Carry out courses of action for good watershed management: riparian buffers.
- It is recommended to evaluate the possibility of intervening using levees or some blue structure to protect the flooded valley from withstanding catastrophic levels since they can lead to greater exposure or vulnerability in areas covered by levees.

- It is recommended to evaluate the possibility of intervening using levees or some blue structure to protect the flooded valley from withstanding catastrophic levels since they can lead to greater exposure or vulnerability in areas covered by levees.[23]
- There are solutions with maximum benefits and cost-effectiveness that would not rely on a hydraulic pumping system to extract floodwater. Both watersheds, rural/urban communities, and the city must consider the value of reforested open spaces to mitigate flood risk.
- Restore the sewer system and maintain the storm drainage system.
- Conduct research on flooding caused by heavy rainfall in excess drainage system capacity and areas where soil permeability is a challenge. Lack of data to represent local sewerage systems, building forms, and infiltration in green spaces would be areas to consider.
- Courses of action to improve the ecosystem and protect the coast. We envision developing projects where citizen participation is ensured throughout the planning and implementation process. Develop strategies to protect and manage coral reefs, plant mangroves, and corals in critical areas. In addition to carrying out projects to protect the dunes.
- It is essential to conduct research on the reef landscape in Puerto Rico and integrate it into public policy concerning coastal flood risk.
- Institutions must evaluate measures to control urban sprawl in flood zones and coastal valleys. Besides, topography should be considered when planning or considering construction. It is recommended that this critical issue be addressed with the exposed communities to participate in the process.
- Consider the most vulnerable populations to go to the neediest places in an emergency and provide the corresponding assistance.
- For water-related hazards, improved hydrodynamic flood modeling is recommended. This approach can be applied in Puerto Rico to assess coastal flood hazards at the Caribbean scale. Partnerships between development and technology-related agencies such as the Puerto Rico Science Technology and Research Trust and federal institutions could be developed to use this model.

For the earthquake risk, it is recommended that:

- Reduce vulnerability in the country's infrastructure, especially critical infrastructure, for example, communication antennas, electrical transmission antennas, highways, PREPA and PRASA's infrastructure, hospitals, among others.
  - Prevent future developments from being exposed to risk by making them seismic-resistant and resilient. This avoids the loss of property and life in the event of a -seismic event.

[23] https://laislaoeste.com/comunidades-se-oponen-a-construccion-de-diques-para-canalizar-el-rio-culebrinas/

- Reduce the amount of infrastructure and buildings in areas vulnerable to risk. For example, in areas where liquefaction risk was recorded in the very high and severe category, as these are more exposed to property and life losses.
- Restore and relocate infrastructure that is in areas that are more exposed to risk or the infrastructure itself is weakened and in need of structural improvements. In this case, hospitals that have been built several decades ago need structural improvements to make the structures seismic resistant. For this purpose, an exercise is carried out to identify federal funds with a matching of local funds.

- Establish planning and design criteria for earthquake risk mitigation to be implemented in the development of new projects and construction of infrastructure such as roads and bridges so that they can be resistant to a seismic event.
- Reduce or avoid exposure and vulnerability of housing in the municipalities.
- Identify communities most exposed to the risk of liquefaction due to earthquakes and acceleration and make a relocation plan for this population.
- Legalize all informal construction around the island through FEMA's Code Enforcement project but emphasize the communities most at risk from earthquakes so that structures can be reinforced and restored.
- Through alliances with the media, community leaders, municipal personnel, and the scientific community where information is distributed on the risk to which the population is exposed, the mitigation and emergency management plans in force so that the population is aware of the risk scenario in which it finds itself.

The risk of failures and faults can cause major disasters. It is essential to create courses of action to mitigate the impact that this can cause. We believe that we must begin to recognize faults and fissures as a real risk that threatens Puerto Rico. Based on this premise, we must educate on the characteristics and behavior of this unpredictable risk. We must also understand the close relationship between earthquakes and fissures. When discussing earthquake issues, it is essential to talk about faults and fissures and vice versa because both risks persist. It is essential to maintain continuous monitoring and documentation of faults and fissures to define risk scenarios associated with them in a more detailed manner.

- It was identified as a limitation that there was not much information available. No complete records or databases were identified that show constant monitoring of the behavior of the faults. No databases detailing the location and characteristics of cracks associated with seismic events were identified. The necessary information cannot be located, such as, for example, when was the last time the fissure was active and recorded of its activity. On the other hand, there are more recognized faults and fissures, such as the Anegada fault and the North Boquerón-Punta Montalva fault due to recent seismic movements in the southern area Puerto Rico.
- More updated information on these faults can be found, but it is still scattered. It was a task and a challenge to gather all the scientific and valid information available to group them in a single document since the information is not centralized. More scientific studies covering other failures are needed to foster a more proactive culture to face the threats of a risk, especially one like this, which is so unpredictable.
- Detailed knowledge of the behavior of faults and cracks will allow a timely risk assessment. The implications of these risks can impact human life, especially the most vulnerable, and on the infrastructure. For this reason, it is necessary to create a database where the accumulation of accumulated deformities along the fault can be shown. It is crucial to maintain an active registry to determine the magnitude of the risk and the most vulnerable communities in the event of an active fault. This project contains a geodatabase with information that could serve as a basis for collaboration.
- Education processes are important. The creation of information brochures has always been a good solution. It would be necessary to attach an action plan with a short, medium, and long-term vision, given its association with earthquakes. This should also be accompanied by a new and updated topographic study to detect the new topographic reality of Puerto Rico.
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Among the preventive actions to reduce vulnerability to drought, it is recommended:

- One of the significant limitations that could be observed is the lack of available data regarding drought in Puerto Rico. The drought monitor does not represent events before 2000. Given this, we lack a frame of reference to help establish the magnitude and intensity with which changes occur in the hydrological conditions of Puerto Rico (reservoirs, etc.). Therefore, it is recommended:
- Database access and creation - Update the water resources status database to ensure that all available information is correct. Public input on the impact of droughts, such as the 2014-16 drought economic analysis study generated by the PRPB, is not freely accessible. If identified, the data layers are outdated because they do not take into consideration events from the last four years, such as school closures.

- Decisions regarding courses of action to be taken depend on up-to-date information.
- Prepare a repository of drought-related data and documents for easy access and cross-analysis. The USDM used does not segregate data individually, so if the information is not monitored locally, detail, such as a change in surface water flow, is lost.
- Document flows create baseline status of water sources and reserves (reservoirs, aquifers, surface flows) and create localized models for Puerto Rico and its regions: The models that can be made depending on the availability of data. However, the necessary information has not been consistently measured or documented, such as surface water flows, the rate of consumption of reservoirs to modify operational limits.
- Implement and monitor minimum environmental flows by region (PIRA, 2016). This would include ecosystem needs, minimum flows, and safe yields for PRASA intakes. This would begin to address the drought itself and not just its causes.
- Study and establish minimum requirements for each operating sector of society, agriculture, tourism, industry, housing, among others.
- There is an assortment of documents, laws, orders, and plans that touch on drought with little overlap between them. Two key documents that guide how to avoid the risk and manage the consequences of drought are the PIRA and the Drought Protocol, respectively. The information in these two documents must be continuously evaluated, updated, and amended against new generated information. Any future public policy recommendations should be based on these documents.
- Drought is a phenomenon that allows us to prevent the manifestation of risk and mitigate its impact. The PIRA provides a panoramic vision of all the systems that affect water resources' quality and availability. It encompasses recommendations at three levels: (1) infrastructure management, (2) land management, and (3) education and awareness. Each level has goals, objectives, and actions to be carried out.
- In summary, drought offers us the opportunity to manage water infrastructure, territory, and work with people to avoid risk and, if it occurs, minimize the impact of its consequences. The PIRA and the Drought Protocol are an excellent first step, offering a panoramic view with recommendations for managing each facet of the resource and creating tools for improved management and monitoring to better prepare for future scenarios. Both documents should be the basis for any future mitigation plan

- The precipitation average is established by the previous 30-year period, large areas, and annual averages (encompassed). This affects that the norm, as climate change continues, may become drier and drier. The lack of regional, specific data does not reflect geographically or temporally localized drought patterns.
- The spatial and temporal discrepancy of risk and impact makes us even more vulnerable, and the risk profile must create mechanisms to address or minimize these mismatches. For example, drought trends begin to be seen in March but are not reflected in reservoirs until summer, worsening risk. Likewise, areas in drought serve distant areas that are not yet experiencing drought conditions, limiting possible attempts to conserve or regulate water use.
- Disaster mitigation does not address the effect of the interaction of physical and social factors or the cumulative impact of multiple consecutive disasters.
- There is no specific drought season, so one must look at extreme events or specific months to determine a drought pattern or risk trend.
- There are no existing courses of action to address drought preventively.

The 2021 PRSNHMP highlights the recommendations included in the CDBG-MIT Action Plan focused in the critical infrastructure as well as another relevant elements like Community Lifelines with the mitigation planning process:

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. An extreme event, such as the 2017 Hurricanes Irma and María, can disrupt a supply chain in three (3) primary ways: demand shift, capacity reduction, and communication disruption.

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 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 Roadways provide access to neighborhoods, residences, and community assets.

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

The CDBG-MIT Action Plan identifies the resilient freeways and expressways in Puerto Rico, that 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. 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.

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. 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. Consequently, the programs under the CDBG-MIT Action Plan encourage localized energy resilience measures across all economic sectors. 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) 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.

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. Investment in renewable energy development could create stability not only in terms of reliable energy, but also jobs and environmental factors.

Communications Lifeline Needs

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 for Communications Lifeline

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.

Stormwater and Flood Mitigation

Puerto Rico receives significant rainfall in most of the Island's 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.192 In addition, there are at least thirteen (13) additional levee systems, likely owned and operated by municipalities, across Puerto Rico.

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.

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.

Additionally, it is important to address an environmental and human health legacy issue, namely that over 40 percent of the population living in Puerto Rico relies upon septic systems to dispose of domestic wastewaters. The prevalence of the septic systems is due to limited resources, soil conditions, and the lack of wastewater infrastructure including sewage piping and wastewater treatment plants. Septic systems are used to treat and dispose of relatively small volumes of wastewater, usually from houses and businesses located in suburban and rural locations not served by centralized public sewer systems.

Septic systems that are properly planned, designed, sited, installed, operated and maintained can provide excellent wastewater treatment. However, systems that are sited in densities that exceed the treatment capacity of regional soils, and systems that are poorly designed, installed, operated, or maintained can cause problems, which is the issue in Puerto Rico.

CHAPTER IV

STATE MITIGATION CAPABILITIES

Courtesy by FEMA

4.1 State Mitigation Responsibilities.

The assessment of mitigation capabilities is the next step after assessing hazard risk. Combining these two elements provides the foundation for developing a comprehensive action strategy to mitigate risks in Puert Rico. The development and strengthening of State organizations and mechanisms are crucial to increasing resilience to threats. The ability to reduce hazards depends on the physical, economic, social, regulatory, and political factors discussed in this Chapter. It provides information on the resources or tools that the State must mitigate natural hazards and support implementing the targets, objectives, and mitigation actions proposed in the 2021 PRSNHMP.

Understanding state government and local authorities and capabilities are necessary to develop a comprehensive and feasible mitigation strategy. Hazard mitigation is implemented through a portfolio of capabilities. These capabilities include regulations, codes, plans, public education efforts, preparedness initiatives, and structural approaches. The Capabilities Assessment represents the Planning Steering Committee's best effort to identify state and local agencies, policies, regulations, plans, personnel, and programs that play a significant role in protecting life, property, and infrastructure. Information in this section as it pertains to Puerto Rico state government was reviewed and updated as necessary as part of the 2016 PRSNHMP update process.

The State's mitigation capability can be described as the resources and tools to reduce or eliminate vulnerability to identified hazards. The state government is responsible, within its statutory authorities, to perform direct activities and help and support to local jurisdictions in identifying risks to hazards. This assistance includes developing and running programs to provide technical assistance and funding to develop and implement mitigation actions to reduce those identified risks. This section offers a discussion of the State government's financial, legal, and programmatic ability to carry out mitigation actions in the pre-and post-disaster setting to achieve its mitigation goals and objectives.

The mitigation capabilities are addressed by evaluating how a program, policy, regulation, or practice contributes to the statewide mitigation program and addresses areas in which the state needs to strengthen its capabilities by providing applicable limitations. The discussion of state capabilities is extended to provide an overview of how they address development in hazard-prone areas and to highlight general changes in capabilities since the approval of the previous Plan. Additional discussion on state government capabilities includes what funding mechanisms are in place to improve or sustain capabilities and implement the mitigation strategy. This discussion consists of assessing funding capabilities for hazard mitigation projects to include their limitations and where additional funding is necessary.

As discussed in **Section 2.1.4**, sixteen (16) public agencies and other organizations are identified as having mitigation responsibilities within the statewide mitigation program. Each agency includes the main activities related to emergency management, land use, housing, infrastructure, economics, health and social services, and capacity building mitigation activities. The following table shows the role of each agency and how each was involved in the planning process and plan development.

Table 4-1. State Agencies and Other Stakeholders' Mitigation Responsibilities.

Department/ Agency	Mitigation Responsibilities
American Red Cross	• The American Red Cross is responsible for providing emergency assistance and rehabilitation in all phases to people affected by a disaster. • It will coordinate with the PREMB Commissioner the work to be done in the emergency and rehabilitation phases to make the best use of the resources and funds available for the care of those affected. • The Red Cross developed a roadmap to guide the risk analysis process, from identifying and describing the risks associated with different response options through cash transfers, classifying the risks according to their severity, and deciding what action to take. Although it will not always be possible to follow all stages in the sequence proposed by this instrument in an emergency context, it does raise the expectation of meeting at least the minimum standards established.
Department of Education	• Identify and implement mitigation measures intended to save lives, reduce harm, and ensure the safety of students, teachers, and non-teaching staff during or after an event natural or technological. • Development of measures to be taken for immediate and effective action in the event of an emergency, including evacuation plans, identification of safe places to mobilize students, communication with support agencies, parents, and people related to the campus, and provisions for the reduction or prevention of hazards to students, teachers and other teaching and non-teaching staff. • Coordinate with the Secretary of Housing to use schools as shelters.
Department of Health	• Lead state agency responsible for coordinating public health and medical response activities and supporting mass fatality response for all-hazard emergency or disaster events. • Maintains role in mitigating hazards related to potential medical surges, water quality problems, stormwater permitting, air pollution monitoring, hazardous materials issues, or monitoring of critical infrastructure such as wastewater treatment plants and drinking water systems. • Provides detection and investigation for disease control and environmental epidemiology. • Develops and coordinates health emergency response plans; assesses natural and human-caused disasters and enhances public health response to those events; integrates public health and medical systems with other local and state partners; trains public health, medical, and emergency response partners on latest and improved protocols related to health, medical, and mortuary response; distributes health information and implements systems for effective, redundant communication among stakeholders involved in public health detection and response.

Department/ Agency	Mitigation Responsibilities
	• Identify or implement mitigation measures that are necessary in hospitals and other health care facilities for the purpose of saving lives, reducing damage, and ensuring continuity of services following a natural or technological event. • Coordinate environmental health services to address health risks created by an emergency or disaster. • Coordinate the use of private sector health resources in emergency or disaster situations. • Conduct inspections required to ensure the quality of water provided to citizens. • Preparedness and Response Plan for COVID-19. This plan describes the activities associated with preparedness and response to a public health emergency in Puerto Rico caused by the detection of COVID-19.
Department of Housing	• Evaluate and recommend alternatives, prepare plans, and implement emergencies or disasters whose purpose is, natural disasters, such as: floods and landslides, among others. • Provide temporary or permanent housing to families and individuals who lose theirs due to a disaster or emergency, as well as how to manage help to make minimal repairs to affected homes. • Works with FEMA, GPR agencies to aid and funds to families whose homes have been destroyed or in need of major repair following a disaster. • Coordinated by the U.S. Department of Housing and Urban Development (HUD) to develop adequate, affordable, and accessible housing solutions for Hurricane Maria survivors. • In charge of administering CDBG-DR funds in close collaboration with the Central Office of Recovery, Reconstruction, and Resilience (COR3). • Develop the CDBG-DR Action Plan to ensure that the use of these funds should ensure the long-term recovery of communities, specifically in areas of housing, infrastructure restoration, and economic revitalization. • Provides various levels of damage assessment for homes and buildings affected by disaster, assists local officials in determining feasibility of repairs.
Department of Natural and Environmental Resources	• Mandated to conserve, protect, promote development, and regulate use and enjoyment of state natural resources related to water, soil and air conservation, management of state lands, wildlife, parks, outdoor recreation, and geological features. • Promotes conservation of waters of the GPR to secure greatest utilization of such waters and utmost prevention of floods.

Department/ Agency	Mitigation Responsibilities
	• Co-Chair and coordination of the Drought Task Force when activated. • Monitors Puerto Rico Comprehensive Water Resources Plan • Promotes efficient water usage, provides public information, technical, and financial assistance for water conservation planning; promotes drought planning, encourages, and assists communities to prepare and implement drought mitigation plans through technical and financial assistance, monitors drought impacts, and informs public, media, and state officials.
Department of Family	• Collect information on the affected population immediately after an emergency or disaster. • Collaborate in determining the type of assistance to be offered to individuals or families in the event of emergencies or disasters whose purpose is, among others, the relocation of families or relocation of structures in high altitude areas risk to natural hazards, such as floods and landslides, among others.
Department of Transportation and Public Works	• Restoring public roads, removing obstacles and debris that obstruct traffic because of the emergency or disaster and the disposition of these. • Provide technical assistance to federal, state, and municipal entities to determine the most appropriate ways or means to transport personnel and supplies to, from and within affected areas. • Maintain and clean the stormwater system ducts on state highways as a risk prevention measure for floods. • Designs bridges, culverts, and highways based on 100-year, 50-year, and 25-year flood design standards; performs benefit/cost analysis and 100-year flood consequence analysis; signs off on all projects and reviews existing work by other agencies; performs additional work necessary to design structures in floodplain. • Reviews, updates, and prioritizes action strategies for statewide, utilizing current USACE and FEMA reports, hydrologic, and hydraulic analyses; performs new hydrologic and hydraulic analyses where necessary, and creates action plans to reduce risks to bridges from scour. • Has expanded the authority and capabilities of its internal Office of Emergency Management to better manage incidents and emergencies across the state. This includes an increased focus on increasing resiliency and mitigating against hazards.

Department/ Agency	Mitigation Responsibilities
DPS Emergency Management Bureau (PREMB)	• Provides comprehensive state emergency management program supporting local government and state agencies; addresses all phases of emergency management supporting all-hazards and disaster emergencies. • Integrates emergency management efforts across all levels of government, including state, local, and federal. • Provides planning and training services to local governments including exercise support, mitigation, domestic preparedness, and disaster recovery, sponsors workshops for local elected officials and staff. • Coordinates state response and recovery program in support of local governments; maintains State Emergency Operations Center (SEOC) where emergency support function (ESF) representatives from other departments/ agencies and federal agencies coordinate response to disaster emergencies. • Facilitates state-level training; works with local agencies to ensure coordination in planning and implementation of local and regional exercises. • Leads the State Hazard Mitigation Team (SHMT). • Leads maintenance of Puerto Rico State Natural Hazard Mitigation Plan.
DPS Fire Department Bureau	• Regulate the safety standards that each structure must comply with either for use residential, educational, commercial, and other by way of mitigation. • Support PREMB in educating the community about the fire prevention, preparation of how to act in case of earthquakes, handling of hazardous materials and other issues. • Provide PREMB and PRPB with information on estimates of fire damage, as collected. • Carry out inspections of all structures to be used as shelters. • Provides fire prevention and code enforcement, wildfire preparedness, response, suppression, coordination and management, training and certification, public information and education, and technical assistance to local governments.
Office of Permits and Management (OGPe)	• Responsible for overseeing that new developments comply with applicable regulations related to the mitigation of natural hazards. • As result of Hurricane Maria, the Administrative Order: 2017 -08 establish the terms of the alternate for the consideration and award of all applications filed in the unified information system (SIU) of the OGPe Permit Office.
Public Buildings Authority	• Collect information regarding damage to public facilities and buildings not assigned to agencies. • Identify and implement mitigation measures whose purpose is to protect and avoid the possibility of loss of those facilities under your jurisdiction that guarantee the continuity or rapid recovery of services after natural or technological events

Department/ Agency	Mitigation Responsibilities
Transportation and Other Public Services Bureau	• Determine transportation capacity to support government entities, voluntary organizations and the contracting of such resources when required through the Puerto Rico General Services Administration. • Enforces state hazardous materials laws, rules, and regulations of transportation by highway; enforces routing, permitting, and safe transportation of hazardous materials; performs spot driver and vehicle inspections to determine compliance with standards. • Identify access routes for the transportation of high-risk materials. • Identify transportation resources and requirements and coordinate its use.
Puerto Rico Electric Power Authority	• Identify and implement mitigation measures whose purpose is protect and avoid the possibility of losses in electrical installations to continue to ensure continuity or rapid recovery of the system after emergencies or disasters. • Inspect, maintain, and take any necessary mitigation measures on water reservoirs or dams under its jurisdiction.
Puerto Rico Planning Board	• Coordinate state efforts to collect, analyze, process, report, and deploy the essential elements of information and facilitate support in planning efforts in emergency operations. • Responsible for education and promotion of the National Flood Insurance Program. • Responsible for the implementation of Planning Regulation No. 13. • Regulations on Flood Susceptible Zones. • To develop and incorporate into current public policies the principles related to the appropriate management of flood plains and the appropriate and safe use of land for the mitigation of natural hazards.
Puerto Rico Ports Authority	• Prepare a plan for early rehabilitation of ports and airports after emergencies and determine alternate use. • Identify and implement mitigation measures whose purpose is to protect and prevent losses at facilities under its jurisdiction. • guaranteeing the continuity and quick recovery of the services after the natural or technological event(s).
Puerto Rico Aqueducts and Sewer Authority	• Identify and implement mitigation measures whose purpose is to protect losses from facilities under their jurisdiction that guarantee the continuity or rapid recovery of the system after natural or technological events. • Inspect, maintain, and take any necessary mitigation measures on water reservoirs or dams under its jurisdiction. • Implement emergency operational procedures at all facilities under its jurisdiction. In addition, maintain communication with PREMB regarding water levels and discharges into dams and reservoirs to act necessary to safeguard lives and property. • Reserve water supplies for use by the Fire Department as required.

Department/ Agency	Mitigation Responsibilities
Telecommunications Regulatory Board	• Coordinate with PREMB to strengthen communications with equipment and technical staff. • Coordinate the restoration of communication facilities and services in the • areas affected by the disaster. • To join efforts for the restoration and reconstruction of the telecommunications infrastructure and to meet the needs in case of emergency. • Establish plans and procedures to manage, assign, prioritize, and use the • communications equipment (State and Federal).
Central Recovery and Reconstruction Office of Puerto Rico (COR3)	• Created as Created as the Colorado Resiliency & Recovery Office (CRRO) following the hurricanes Irma and Maria as a division of the Puerto Rico Fiscal Agency and Financial Advisory Authority. • Supports and helps empower Puerto Rico communities in building stronger, safer, and more resilient in the face of natural disasters and other major challenges. • Maintains www.recovery.pr website to provide open access to information from federally funded recovery programs and resources for individuals and local governments. • Support PREMB in the maintenance and update of the Puerto Rico State Natural Hazards Mitigation Plan. • State Reviewer for the Local Hazard Mitigation Plans.

4.1.1 Administrative and Operational Capability.

The public policy of the Government of Puerto Rico for emergency situations affecting the Island, established in Law Number 211 of August 2, 1999, known as the State Agency for Emergency Management and Disaster Administration of Puerto Rico Act, as amended, is to protect the population in emergency or disaster situations that affect the Government of Puerto Rico and that the necessary assistance is provided in the fastest and most effective manner to protect them before, during and after these disasters by ensuring the protection of life and property[24].

In addition, it is the Government's obligation to achieve the earliest possible recovery and stabilization of the necessary services to citizens, industries, businesses, and government activities. Law No. 211 created the Puerto Rico Emergency Management Administration (PREMA) and empowered it to implement public policy and coordinate all relevant state, municipal, private, and federal plans. As mentioned in Chapter 1, the main purpose of PREMB is to manage emergencies caused by natural or human hazards, as well as to carry out activities to prevent and mitigate it. Its comprehensive vision can articulate coordinate activities through four (4) phases: preparedness (before), mitigation (before and after), response (during), and recovery (after). The PREMB mission is to coordinate all government resources of the Government of Puerto Rico, as well as those of the private sector, to provide services quickly and effectively in advance, during, and after emergencies to ensure the protection of life and property of citizens[25].

Pursuant to Law No. 20 of April 10, 2017, also known as the Puerto Rico Department of Public Safety Act, the "Puerto Rico Emergency Management Bureau" (PREMB) was created under the direct and non-delegable supervision of the Department of Public Safety[26]. Notwithstanding this change, PREMB maintains its responsibility for managing emergencies in Puerto Rico in their different phases: planning (before), preparedness (before), mitigation (before and after), response (during) and recovery (after), and offering

[24] State Agency for Emergency Management and Disaster Administration of Puerto Rico Act.

[25] Puerto Rico Emergency Management Bureau (PREMB, by its Spanish acronyms).
http://www.manejodeemergencias.pr.gov/#mision

[25] "Article 7 of Law 20-2017, establishes that among the powers of the Director, is the "(o) Develop and maintain a State Emergency Management Plan for all phases of emergency and disaster management, coordinating the actions of state agencies and municipalities in order to provide the earliest possible provision of essential services to meet the needs of our citizens and their restoration as soon as possible; and (r) Respond to the planning program for the mitigation of both natural and technological hazards. To this end, he shall chair the Inter-Agency Committee for State Risk Mitigation, established by Article 11 of this Law. Similarly, he will serve as the State Mitigation Officer of the Government of Puerto Rico. This will appoint an Alternate Mitigation Officer to assist you in discharging the functions required by this Act."

services to citizens in the face of natural, technological, or man-made events. After Hurricane Maria and to continue exercising its functions within the applicable laws, rules, and regulations, the COR3's Office was created through an Executive Order[27] as the pass-through entity that provides a sub-award for DR-PR-4336 (Irma), DR-PR-4339 (Maria), DR-PR-4473 (Earthquake) and DR-PR-4493 (COVID-19). The COR3 absorbed the PREMB Office of the Governor's Authorized Representative (GAR) that it is represented in all states and territories. Thus, the GAR now sits in COR3, and it is the office that manages all mitigation projects under Public Assistance 406, the Hazard Mitigation Grant Program (HMGP) and Pre-Disaster Mitigation (PDM) programs, respectively, and the management and direction of all-hazard mitigation projects under the abovementioned programs.

Also, PREMB offers its services on an island-wide basis through Operational Zones. The ten (10) Zones, organized in three (3) regions, foster rapid response and attention closer to the communities. The distribution of the zones is as follows: Region I (Zones of San Juan, Caguas, Ceiba, and Humacao); Region II (Zones of Aguadilla, Arecibo, and Vega Alta); and Region III (Zones of Guayama, Ponce, and Mayagüez).

4.1.2 Hazard Management Plans.

In terms of pre-disaster and post-disaster hazard management plans, PREMB had a State Response Plan. After Hurricane Irma and Maria, the government has joined the private sector and non-governmental sectors to create the new Joint Operational Catastrophic Incidents Plan of Puerto Rico (JOCIP)[28]. This initiative is based on lessons learned and best practices that were carried out during the most severe hurricane that had impacted Puerto Rico in the last nine decades.

Each state agency that is part of the Interagency Committee for State Emergency Management has a Recovery Plan that is coordinated and integrated into the State Response Plan. These plans are aimed at ensuring the continuity of services. PREMB (and COR3) also has a State Mitigation Plan (2021 PRSNHMP), which is being updated with this document:

2021 PRSNHMP. Each state agency that is part of the Interagency Committee for the Mitigation of Natural and Technological Hazards carries out natural hazard mitigation activities coordinated by PREMB and COR3. The Agencies are required to complete a periodic process of updating their mitigation plans.

[27] Boletín Administrativo Núm. OE-2017-65. Orden Ejecutiva del Gobernador de Puerto Rico, Hon. Ricardo A. Rosselló Neváres.
[28] Puerto Rico Emergency Management Bureau (PREMB) and Puerto Rico Department of Public Safety. Joint Operational Catastrophic Incident Plan of Puerto Rico. June 2019 Version 1.10.

On the other hand, each Municipal Emergency Management Office (OMME by Spanish acronyms) has its Operational Emergency Plan, which is coordinated with the State Response Plan. OMMEs are also responsible for carrying out pre-disaster and post-disaster mitigation activities in their respective territories.

Local government (municipalities) develop Local Hazard Mitigation Plans (LHMP) that are updated every five (5) years. As a result of the declaration of a major disaster, the Puerto Rico Planning Board (PRPB) was designated by the GAR as the responsible agency in charge of reviewing and developing the LHMP.

PREMB, together with the GAR, is responsible for ensuring the development and implementation of 2021 PRSHNMP. For this purpose, in addition to the internal administrative, legal, and economic resources, it has the resources and tools that exist in the State to support the mitigation of identified hazards and reduce or eliminate the vulnerability to which we are exposed. The most relevant laws, regulations, and programs related to hazard mitigation are discussed below.

Currently, there are five (5) types of plans to manage the risk mitigation issue:

- State Hazard Mitigation Plan: The Puerto Rico State Hazard Mitigation Plan identifies the natural hazards that could potentially affect the Island. The SHMP assesses risk and vulnerability to these hazards and identifies top priority mitigation actions at the State level.
- Local Hazard Mitigation Plan: Local Hazard Mitigation Plans are used to identify policies and actions that can be implemented over the long term to reduce risk and future losses. Mitigation Plans form the foundation for a community's long-term strategy to reduce disaster losses and break the cycle of disaster damage, reconstruction, and repeated damage.
- Joint Operational Incident Catastrophic Plan: JOCIP is the framework for coordinating state and local capabilities to support local jurisdiction response with state-level resources in compliance with Federal guidelines.
- The Puerto Rico Emergency Operational Plan: is the official document for the prevention, preparation, mitigation, response, and recovery of any incident, event, emergency, or disaster within the GPR jurisdiction. The Hon. Alejandro Garcia Padilla approved it on September 28, 2016. Its application is mandatory for all agencies, corporations, and offices of the state and municipal government, political subdivisions, the private sector, and non-governmental organizations that operate or respond to emergencies in Puerto Rico. This plan comprises Specific Hazard Annexes, whose Hurricane Annex was considered for the 2021 PRSNHMP update.

- Local Emergency Management Plan: Under CFR, municipalities must develop all-hazards plans to guide municipal emergency management operations[29]. A current local emergency plan is also required for municipalities to receive increased state reimbursement through the Emergency Relief and Assistance Fund (ERAF).
- Community Development Block Grant – Mitigation (CDBG-MIT) Action Plan: The CDBG-MIT 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, Community and Regional Investment, Lifeline Stability and Strengthening, and Alignment of Capital Investments.
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4.1.3 Hazard Analysis Capability.

The analysis tools in the hands of the State define its capacity to analyze and mitigate the identified hazards. To the extent that the Government of Puerto Rico is clear about the identification and analysis of risks, it will be able to establish mitigation measures that guarantee greater levels of security and reduction of vulnerability. There are several tools and methodologies used for risk identification and analysis; however, three methodologies are recognized whose main analysis tools are managed and promoted by the PRPB, where each provides estimates for the potential impact of hazards using a common and systematic framework for assessment:

- Stochastic risk assessment.
- Geographic Information System (GIS) based analysis.
- Risk modeling analysis.
- Benefit-Cost Analysis (BCA)
- Recovery tools developed by the federal government.

At the same time, the development of the risk assessment of this Plan also uses the tool of the Federal Census Bureau, specifically of the 2010 census block. This is so since this block provides detailed data on the population and demographic characteristics of the municipalities, specifically through segments such as race, origin, age, and housing units. Likewise, the 2010 Census is used because it is the last certified census at the time of the development of this Plan. Any other data provided by the Federal Census Bureau, such as data from the American Community Survey, refer to limited projections or estimates and is used in this plan as a trend.

[29] . 44 CFR § 201.6 - Local Mitigation Plans; (a) Plan requirements.

Although these analytical tools are discussed below, all resources involved in the management and analysis of hazard-related information, ranging from equipment, data, written reports, and human resources, define the State's capacity to analyze and mitigate the identified hazards. A description of the three (3) approaches used for the analysis, focus, and development of this plan is provided below.

Stochastic Risk Assessment.

The stochastic risk assessment methodology is used for the analysis of risk hazards that are not covered under the studies provided by the hazard risk models and the risk assessment of the GIS system because it considers the annual loss estimates and information obtained on the impact.

The annual loss represents the long-term weighted average value of property losses in a single year and in a specific geographic area (such as a municipality). This methodology is mainly applied to hazards that have no defined geographical boundaries and are, therefore, excluded from the GIS analysis. The stochastic risk methodology is used for the following hazards:

- Drought.
- Wildfires.

Drought is considered an atmospheric hazard and has the potential to affect all current and future buildings and populations. Estimates of annual losses for the drought hazard are determined using the best available data on historical losses according to sources such as reports from the National Oceanic and Atmospheric Administration's (NOAA) National Environmental Information Center and local knowledge. Annual loss estimates are generated by adding up the amount of property damage during the period for which records are available and calculating the average annual loss.

Geographic Information System (GIS) based analysis.

In Puerto Rico, Law No. 398 of September 9, 2000 (“Ley para crear el Comité Coordinador para la Adquisición y Acceso a Información Geográfica de Puerto Rico”) created the Geographic Information System as a central digital system of integrated geographic information and maps that interrelate different information banks and serves as a depository of all geographic information acquired, purchased, or produced by any government agency. The PRPB administers the GIS Program as a geographic data information center for the Government and the public. The main functions of the GIS are as follows:

- Optimize tools to make the geographic information produced by government agencies fully accessible through the Internet.

- Promote the responsible, coordinated, and standardized use of spatial data so that geographic information is useful to its multiple users.
- Update Puerto Rico's spatial data in cooperation with the different state agencies, OFAs, and local government.
- Facilitate and promote the use of standards and best practices in the collection, production, distribution, and use of geographic data at the interagency level.
- Introduce GIS functionalities in the daily processes of government and private entities.

Hazards with specific geographical boundaries allow a GIS-based analysis is used for the following hazards:

- Flooding
- Landslide
- Extreme Winds
- Earthquake

The objective of the GIS-based analysis is to determine the estimated vulnerability of critical facilities and the population. In that direction, the PRPB's GIS Program manages the following projects to promote the analysis of different factors that affect the environment. Among them:

- Interactive Environmental Assessment Portal / "Puerto Rico Interactivo".
  Geographic analysis tool that allows the location and evaluation of environmental and physical characteristics of a particular place and provides information on development policies associated with land in Puerto Rico.
- ESRI® ArcGIS.
  To assess hazard vulnerability using the digital risk data and hazard information database mentioned above, ESRI® is used ArcGIS™ 10.8. Using these data layers, hazard vulnerability is quantified by estimating the number of critical facilities, buildings, and the population located in hazard-prone areas. This method is subject to overestimation of risk exposure, particularly in terms of population data. This is so since the source of population data comes from the 2010 Census, as it is the only source that uses the census block level, a population that has decreased in the years following 2010.
- Risk modeling analysis.The vulnerability modeling program is recommended for use in the following hazards:

1. Earthquake
2. Flooding

   Several programs exist to model risk vulnerability. This Plan includes the Hazus-MH program for vulnerability assessment concerning the hazards outlined above.

- HAZUS Multi-Hazard (HAZUS-MH)
  An analysis model that seeks to identify those properties located in areas vulnerable to natural hazards. HAZUS-MH combines math, science, and engineering with GIS to estimate life and property losses and represent them on a map. The project is worked in coordination with PREMB. It is built on an integrated GIS platform to perform analysis at a regional level (i.e., not structure-by-structure). The HAZUS-MH risk assessment methodology is parametric in the sense that various hazards and inventory parameters (i.e., depth of flooding and type of building) can be modeled using the program to determine their impact. For example, some impacts can be damage and loss to build-up areas. HAZUS model last run for the whole island was worked on between 2014 and 2015. In the short term, there are no expectations from the PRPB to carry out another one.

The HAZUS-MH version 4.2 SP1 is used to estimate possible flood damage, and the HAZUS-MH version methodology to estimate earthquake damage. The program can also be used to estimate losses caused by hurricane winds (category and/or speed), as well as tsunamis. This model is known as the HAZUS Wind Model.The following figure illustrates the conceptual model of the methodology for estimating the impact of a given risk under the HAZUS-MH model. HAZUS-MH could provide a variety of loss estimation results. This model is used both at the state level and for local plans:

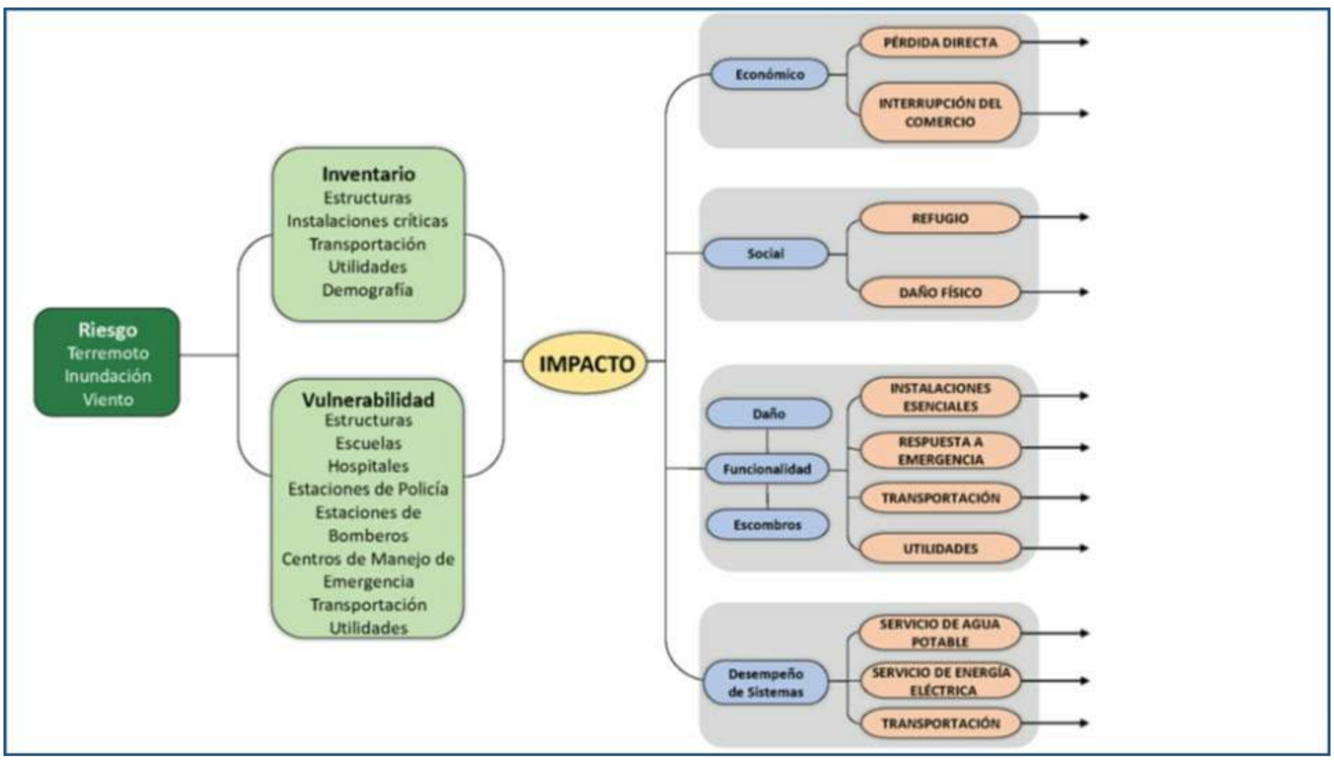

Figure 4-1. Conceptual Model for HAZUS-MH Methodology. Source: HMP Local Plans developed by PRPB/Atkins

The damage reports from Hurricanes Irma and Maria in Puerto Rico recommended creating micro-zone wind maps considering the topography of Puerto Rico. The Puerto Rico Topographic Wind Speed-Up Microzoning Methodology, commissioned by FEMA, the STARR II consulting firm, University of Florida, University of Puerto Rico-Mayagüez Campus, and Applied Research Associates (ARA), incorporates those recommendations.

With Hawaii being the first jurisdiction with a similar micro-zone study, this study advances technologies implemented in the 2020 review cycle of the Puerto Rico Building Code. The study used wind acceleration

factors considering the topography and vegetation of Puerto Rico. The historical data and statistical projections used sixteen (16) different directions (impact possibilities) to create hurricane wind patterns. As a result, the study incorporated unique micro-zone wind maps as an amendment to the wind speed maps provided and facilitate construction design according to a specific project's location.
The study reflects a base wind average of 140 mph over wind points recorded above 250 mph, concluding that only 13% of Puerto Rico is exposed to winds above 187 mph. The study contains 316 maps (four (4) general, four (4) risk categories for the 78 municipalities) in which it demonstrates the impact of winds with the revision of the 2011 PR Building Code, which established 145 mph as a wind parameter.

This study complements the HAZUS model used for extreme wind risk assessment, presented in previous section and **Chapter 3** of this Plan.

Dam Safety Risk Analysis.
In Puerto Rico, periodic inspection of all dams is required under the Federal Guidelines for Dam Safety. This is a comprehensive, periodic dam safety review that documents the condition of the dam at a point in time should incorporate a risk analysis to enhance the value of the effort. Additional analyses and studies are typically not performed specifically for periodic risk analysis because the analysis relies on existing information. A periodic risk analysis focuses on all potential failure modes that are considered credible at the dam. Periodic dam safety reviews are performed on a recurring cycle, with the interval between assessments determined by the agency.
Flood Insurance Risk Maps (FIRM).

The Flood Insurance Rate Map (FIRM) is the official map prepared and approved by the Federal Emergency Management Agency (FEMA) and adopted by the PRPB in 2005 to designate the areas with a risk of 1% flood probability occurring or exceeding each year. As part of its many duties and responsi bilities, the PRPB is the government entity responsible for establishing safety measures to regulate buildings and the development of land in the areas declared as Special Flood Hazard Areas. Among its main functions for the operation of flood valleys, the PRPB analyzes, evaluates, determines, and regulates the uses and activities that can occur in areas at risk of flooding. This includes the use of flood insurance rate maps (FIRMs) as tools for identifying areas at risk of flooding.

These maps are prepared and approved by the FEMA, prior to being adopted by the PRPB as an official delimitation from flood risk areas. The FIRM shows the following:

- Community identification number, Panel Number, Map Effective Date, Base flood elevation (BFE) for the areas studied by detailed methods. For Puerto Rico, also the SFHA with the symbols A, AE, VE, AO, AH, A99, and for areas that are outside the SFHA are those identified with an "X".

This product serves as an instrument for the management of special flood hazard areas, which most of shown on the FIRMs are based on technical-scientific studies of flood insurance known as Flood Insurance Studies (FIS). They are used to apply flood insurance rates.

Advisory Base Flood Elevation Maps (ABFE).
Following Hurricane Maria, FEMA, in coordination with the Puerto Rico Planning Board, worked on new flood zone maps to make the most up-to-date flood information available. These maps are known as Advisory Maps. These maps show the recommended base flooding levels (ABFE) developed for Puerto Rico, corresponding to the 1% probability flood of occurring each year. They identify areas that are in new flood zones, identified from the effects of Hurricane Maria based on analyses and data. Main objectives are to provide data based on the best information available to determine how to elevate structures to rebuilt and to minimize future flood damage, and to establish which portions of the communities are within the new flood zones.

The product was developed using modern engineering methods but does not replace current effective Flood Insurance Rate Maps (FIRMs) for insurance-related matters. It includes updated estimates of the following annual chance flood elevations: Coastal: 0.2%, 1%; Riverine: 0.2%, 1%, 2%, 4%, and 10%, reflecting higher flood elevations than shown on current effective FIRMs and extend beyond the Special Flood Hazard Areas (SFHAs) shown on current effective FIRMs.

The additional benefits that bring the ABFEs are that it has accurate information available after a disaster to be used for reconstruction and recovery efforts. Also, the information is more updated than that of the current FIRMs, which do not fully reflect the current flood risks. Elevating above the advisory base flood elevations can reduce flood risk and provide a better return on investment when rebuilding homes affected by hurricanes.

In Puerto Rico, the adoption process started on March 23 and ended on July 12, 2018 with the adoption via Administrative Order JP-ABFE-02. The process included Thirteen (13) meetings related to ABFEs Maps using PREMB zones, Municipalities (planners, permits officials, first responders), state agencies, realtors, and communities.

The main changes that ABFEs reflect are basically in the Coastal A Zone, which includes areas of coastal flood hazard with an annual probability of 1%, subject to waves of heights between 1.5 'and 3', where the waves can cause damage to certain structures and currently are not identified in Puerto Rico's FIRMs. Besides, ABFEs maps include this designation, as well as the Limit of Moderate Wave Action (LiMWA) that marks the limit of the Coastal A Zone. In addition, the parameters established for VE Zone in Regulation 13 also apply to any new construction or substantial improvement in the Coastal A Zone (LiMWA). Additional changes were identifying such as: Zone As now show ABFEs; Some X zones are now AE zones; Some AE zones are now Coastal A zone; and Some areas are newly mapped in the SFHA.

The purpose of these maps is to serve as a tool for professionals in charge of developing new communities to make informed decisions based on possible settlements, their infrastructure, and their vulnerability. These maps are not a substitute for the FIRMs for flood insurance determinations of the National Flood Insurance Program.

Benefit-Cost Analysis (BCA).

The FEMA's Benefit-Cost Analysis (BCA) programs guidelines, methodologies, and tools for the Hazard Mitigation Assistance (HMA) and Public Assistance (PA) grant programs. The Benefit-Cost Analysis (BCA) is the method by which the future benefits of a hazard mitigation project are determined and compared to its costs through guidelines, methodologies, and tools for Hazard Mitigation Assistance (HMA) and Public Assistance (PA) grant programs. The result is a Benefit-Cost Ratio (BCR), which is calculated by a project's total benefits divided by its total costs. The BCR is a numerical expression of the "cost-effectiveness" of a project. A project is cost-effective when the BCR is 1.0 or greater, indicating the benefits of a prospective hazard mitigation project are sufficient to justify the costs.

FEMA requires a BCA to validate cost effectiveness of proposed hazard mitigation projects prior to funding. There are two drivers behind this requirement: (1) the Office of Management and Budget's (OMB) Circular A-94

Revised, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs" and (2) the Stafford Act[30].

The Benefit-Cost Tool Version 6.0 is used to perform benefit-cost analysis for applications submitted under FEMA's Hazard Mitigation Assistance grant programs.

Recovery tools developed by the Federal Government to support Mitigation Capacity.
As Puerto Rico begins to transition from the response phase to recovery, FEMA appointed a Federal Disaster Recovery Coordinator (FDRC) to work closely with the government of Puerto Rico and federal response leadership to facilitate disaster recovery coordination and collaboration between Puerto Rico, federal and municipal governments, private sector entities, and voluntary, faith-based and community organizations. Due to the complex recovery challenges of Hurricane Maria, the federal government leverages all available resources in support of Puerto Rico's recovery efforts. Areas of focus will include:

- Housing: coordinated by the U.S. Department of Housing and Urban Development (HUD) to develop adequate, affordable, and accessible housing solutions for Hurricane Maria survivors.
    - Housing Landslide Working Group. As a result of gaps that are not addressed by public assistance programs to address landslide vulnerabilities and risks, the FEMA-IRC Housing RSF created the Housing Landslide Working Group to unite Federal, State and Municipality, Mitigation and Recovery planning efforts by providing technical support, data, resources, and information, to advocate for a holistic, integrated and sustainable landslide vulnerability and risk analyses process that can help facilitate access to Federal and State Mitigation (404, 406, CDBG-DR) funding opportunities to protect homes, communities, and infrastructure in imminent danger of landslides.
- Infrastructure Systems: coordinated by the U.S. Army Corps of Engineers to efficiently facilitate the restoration of infrastructure systems and services to support viable, sustainable communities and improve resilience to, and protection from, future hazards.
- Economic Recovery: coordinated by the U.S. Department of Commerce, to assist with sustaining or restoring businesses and employment in the affected area and developing economic opportunities in these communities.

[30]U.S. Office of Management and Budget. Circular A-94 Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs. Revised November 2016. https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/a94/a094.pdf

- Health and Social Services: led by the U.S. Department of Health and Human Services, to support locally led recovery efforts to address public health, health care facilities and coalitions, and essential human services.
- Natural and Cultural Resources: led by the Department of Interior, will work with communities wishing to preserve, protect and restore natural and cultural resources—such as historic structures—during recovery.
- Community Planning and Capacity Building: coordinated by FEMA to facilitate support among a variety of partners for the planning, capacity, and resilience-building capabilities needed by state or local governments following this disaster.
  - Participatory Cartography. As a strategy to support building GIS and mapping capacity, FEMA-CPCB understands that geographic Information Systems (GIS) have been an essential decision-making tool for transportation, land use, urban planning, environmental, hazard, and risk analysis. Further, for the emergency management cycle (preparedness, response, recovery, and mitigation), having comprehensive GIS data is essential to support public safety, emergency response, and community planning following a disaster. For local government, the lack of GIS capacity hinders not only its capacity for planning, but also for mitigation and resilient recovery. Along with the importance of having access to GIS, developing mapping (cartography) capabilities is also crucial to strength a transparent, innovative, accessible, transformative, and sustainable recovery planning process. Therefore, supporting the development of a primary set of mapping skills within local governments and community-based organizations can provide them with more planning tools that aim to improve outreach, community engagement, and public participation in the decision-making process.
  - CPCB has successfully used mapping exercise to assist municipal officials in the identification of their need, risk exposure, and project opportunities. While the community mapping exercise conducted with some community-based organization has helped to understand what the priorities and community urgent needs are, such as road access between vulnerable populations and health facilities. The projected outcome is to facilitate a strategy for building GIS and Mapping Capacity. CPCB can coordinate a working group, or task force the reinforces the interagency coordination within COR3, Planning Board, Vivienda (DOH), and UPR-EGP, as such, to sustain long-term support.

These federal agencies work with other support agencies for long-term recovery with a unique focus on restoring communities, local economies. To this end, they have made available to the GPR a database containing digital resources and tools that serve to support both state and local governments in decision-making for the mitigation of natural hazards and risks. **Appendix 4-1** contains the complete list.

4.1.4. Rural Areas, Hazard Mitigation, and Recovery.

Rural areas may be particularly vulnerable to disasters due to poverty, declining population, weaker planning, and administrative capacity, and geographic isolation[31]. "Although disaster losses frequently occur in rural and agricultural areas, a significant majority of the existing disaster research has focused on urban areas and coasts, often overlooking rural populations and communities."[32]

In terms of disaster vulnerability and recovery, research tends to characterize rural communities as either having more limited capabilities than urban areas, where they are under-resourced, and with little capacity to anticipate, cope, and adapt to disasters; or have a greater sense of self-reliance, stronger social bonds, a defined sense of community, and access to nature.[33] Factors affecting rural vulnerability in the context of disasters include racial and economic disparities. Although rural communities may have an advantage in terms of having a less complex local government landscape to navigate in disaster recovery, "this advantage may be eliminated by the concurrent difficulties that arise in interacting with disaster recovery mechanisms that require a certain amount of cash reserves and staff capacity[34]." In addition, rural areas limited development may confer another advantage. However, the lack of building codes in rural areas may represent greater detrimental impacts in terms of disaster recovery that need to be considered.

Research in rural areas following disasters has found a greater increase in housing growth as opposed to suburban areas[35]. Rising housing costs and affordability after disasters force vulnerable populations to migrate from urban to rural areas. Hazard mitigation plans in rural counties are of lower overall quality than plans developed by urban jurisdictions. Rural plans can be weak in certain key principles of plan quality, including the goals, fact base, policy, and participation principles.

[31] Horney J., (2013). Understanding rural vulnerabilities to natural hazards: mitigation plans, planning process and outcomes, UNC Institute of Environment, University of North Carolina at Chapel Hill. Retrieved from Understanding Rural Vulnerability to Natural Hazards: Mitigation Plans, Planning Process and Outcome- UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

[32] Jerolleman, A. (2020). Challenges of Post-Disaster Recovery in Rural Areas. In: Laska S. (eds) Louisiana's Response to Extreme Weather. Extreme Weather and Society. Springer, Cham. https://link.springer.com/chapter/10.1007/978-3-030-27205-0_11

[33] Ibid.

[34] Ibid.

[35] Ibid.

These factors may be attributable to the fact that urban areas typically have a greater existing capacity to plan overall, such as more full-time equivalent staff or more certified planners that can be leveraged into hazard mitigation[36].

The impact that disasters may have on rural areas requires strengthening mitigation plans for these locations. Targeting socially vulnerable populations in hazard mitigation planning can lower human and financial costs over the long run[37]. Therefore, it is necessary for this Plan to consider the various laws pertaining to rural areas and hazard mitigation under Puerto Rico and federal laws.

Land Act of Puerto Rico (Law 26-1941, as amended in 2019).

The Land Act of Puerto Rico, Law No. 26 of April 12, 1941, as amended, seeks to promote the well-being of the inhabitants of Puerto Rico through economic stability, social justice, and economic freedom for farmers, workers, and inhabitants in general, in rural Puerto Rico, providing a better distribution of agricultural wealth.

By means of the approval of Law No. 40 of June 2, 2019, Chapter VII is added to the Land Law of Puerto Rico, Law No. 26-1941, as amended. Chapter VII transfers the Rural Infrastructure Program to the Land Authority, which in turn, is obliged to provide permanent improvement services to the participants of the Family Farm Program.

The Rural Infrastructure Program was established to improve the quality of life of farmers and rural areas and promote agricultural development by providing facilities and utilities like those of the metropolitan area. Amongst permanent improvement services to be provided are included: home repair, construction of retaining walls in collapsed residences; design, construction, establishment, and operation of rural aqueducts independent of PRASA, which are used to provide drinking water to communities in rural Puerto Rico (Articles 81, Law 26-1941). The budget for the Rural Infrastructure Program falls under the budget of the Land Authority (Articles 84 & 86, Law 40-2019). Rural zones are defined by the eligibility maps of U.S. Rural Development of 2015 or the towns in the Agriculture Value

[36] Ibid.

[37] Horney, J., Nguyen, M., Cooper, J., Simon, M., Ricchetti-Masterson, K., Grabich, S., Salvesen, D. & Berke, P. (2013). Accounting for vulnerable populations in rural hazard mitigation plans: Results of a survey of emergency managers. Journal of Emergency Management, Vol. 11, No. 3. Retrieved from https://www.researchgate.net/publication/258248378_Accounting_for_vulnerable_populations_in_rural_hazard_mitigation_plans_Results_of_a_survey_of_emergency_managers?enrichId=rgreq-0a9e4780d0451784c8a640e8db9f00b0-XXX&enrichSource=Y292ZXJQYWdlOzI1ODI0ODM3ODtBUzoyMDU0Njc4MTgxNzI0MTZAMTQyNTk5ODc1MzUzNg%3D%3D&el=1_x_3&_esc=publicationCoverPdf

Zones as established in Map No. 9 of the PUT of 2015 (Articles 81, Law 26-1941).

Reorganization Plan for the Department of Agriculture (Law No. 4-2010 as amended).

The 2010 Reorganization Plan for the Department of Agriculture, Law No. 4 of July 26, 2010, as amended, recognized as part of the public policy of the government of Puerto Rico that the farmers were the principal axis in the development of the agricultural area, which should move to develop intense and precise agriculture, responsible with the environment and the rural surroundings, economically viable and of high demand. This law also transfers to the Land Authority the Family Farm Program, as well as the titles of lands belonging to the Rural Development Corporation.

The law takes steps to establish Puerto Rican food security. As such, it declares as the public policy of the Government of Puerto Rico that the supply of healthy and wholesome food that fosters balanced nutrition for our citizens, renewable energy options for our consumers, and service offerings to the constituent must be ensured and that our farmers are the productors for excellence to serve those needs.

Agricultural Insurance Law of Puerto Rico (Law No. 12-1966, as amended).

The Agricultural Insurance Law of Puerto Rico, Law No. 12 of December 12, 1966, as amended, created a corporation known as "Puerto Rico Agricultural Insurance Corporation" with legal personality separate and distinct from the Government of Puerto Rico, empowered to provide agricultural insurance to farmers against losses or damages to plantations, crops, animals and others structures and equipment for agricultural uses in rustic farms, caused by natural hazards, such as cyclones, abnormal droughts, and uncontrollable diseases, when the Board of Directors of the same so deems appropriate.

Puerto Rico Landslide Risk Mitigation Protocol Law (Law No. 24 of March 18, 2008).

Puerto Rico Landslide Risk Mitigation Protocol Act (Law No. 24 of March 18, 2008) entrust the State Agency for Emergency Management in coordination with the DNER, DTPW, PRPB, and UPR-Mayagüez Campus implement and develop a Protocol for Landslide Risk Mitigation.

Landslides mainly are common mainly in the mountainous area of Puerto Rico, where the origin of most of these is associated with heavy rains or because of factors such as soil erosion, hurricanes, and earthquakes, among others. This law defines landslides as "slow or sudden movements of landmasses, rocks or other materials along slopes such as mountain slopes, gorges, and river channels; that can be caused both by natural causes as a consequence of human activity and by the collapse of the land due to collapse of sinks or high precooling in karst soils."

4.2 State Mitigation Policies, Regulations, Practices, and Programs.

The GPR agencies were requested to review, revise, and update capabilities from the previous plan and provide a discussion on accomplishments as well as limitations. This section and its tables identify the funding and incentives, tools and data, technical assistance and training, and regulations that influence hazard mitigation in Puerto Rico. The result of this robust process is the State capability inventory, which also identifies changes from the 2016 PRSNHMP, areas for improvement, and any strategies or actions that address the capability in this update.

This Section addresses capability-specific areas for improvement, ensuring that State programs support hazard mitigation goals through a comprehensive audit of all State and Federal funding and technical assistance programs will allow partners to develop a set of planning principles to resolve potential conflicts and create synergies between these programs. Additionally, the 2016 PRSNHMP review of capabilities identified many data gaps that inhibit GPR's ability to more comprehensively understand and, therefore, more effectively address hazard vulnerability. Accordingly, implementing the strategy to coordinate hazard mitigation mapping, data, and research will have significant, positive impacts on improving existing capabilities and potentially creating new capabilities where Puerto Rico is otherwise lacking. Administration of specific programs, including Hazard Mitigation Assistance, Public Assistance, and National Flood Insurance Program, among others, are further detailed throughout this section.

4.2.1 State Legal Standards and Regulations for Hazard Mitigation.

Article II of the Constitution of Puerto Rico contains the Bill of Rights. In **Section 19** of said article, it is established that "the power of the Legislative Assembly to enact laws for the protection of the life, health and general welfare of the people shall likewise not be construed restrictively." Accordingly, the Legislative Assembly has enacted diverse laws, regulations, and public policies geared towards the protection of the life and general welfare of the people during emergency situations, natural disasters, and risks mitigation during the occurrence of natural disasters.

The following information is a review of the legal standards, laws, and regulations related to risk mitigation applicable to the Government of Puerto Rico.

The Puerto Rico Oversight, Management, and Economic Stability Act (PL 114-187).

On June 30, 2016, the Congress of the United States enacted "The Puerto Rico Oversight, Management, and Economic Stability Act" (PROMESA), Public Law 114-187, June 30, 2016, 130 Stat. 549, 114th Congress. By way of this Bill, Congress created a structure for exercising federal oversight over the fiscal affairs of territories. PROMESA established a Fiscal Oversight Management Board (FOMB) with broad powers of budgetary and financial control over Puerto Rico and its territorial instrumentalities; created procedures for adjusting debts accumulated by the Puerto Rico government and its instrumentalities; and expedited approvals of key energy projects and other "critical projects" in Puerto Rico.

The FOMB is empowered to: accept, use, and dispose of gifts, bequests, and donations of real and personal property for aiding its work; issue a certificate of compliance once it approves the government's fiscal budget; review any proposed legislation and all enacted laws passed by the territorial government for consistency with the budget and fiscal plan, and if an enacted law is found to be inconsistent with or will interfere with the enactment of the fiscal plan and budget then the Oversight Board may take action to prevent the enforcement or application of the law.

Specifically, Title 5 of PROMESA, Sections 501-507, establishes the dispositions affecting infrastructure revitalization and the identification, approval, consideration, permitting, and implementation of "critical projects" related to addressing an emergency.

- Any critical project, as defined in Title V Sec. 501, must be expedited, and streamed according to the provisions of Puerto Rico Act 76-2000.
- For any critical project that may affect the implementation of Land-Use Plans, as defined by the Puerto Rico Act 550-2004, the PRPB will be required to decide within a sixty (60) daytime-frame. If PRPB determines that the project is inconsistent with relevant land use plans, then the project will be deemed ineligible for critical project designation.

The GPR is bound by PROMESA. Since the FOMB have broad powers of budgetary and financial control over Puerto Rico and its territorial instrumentalities, GPR needs to have a coherent budget for different hazard mitigation scenarios, approved by the FOMB, so when an emergency arises, the government's ability to implement the hazard mitigation plan is not hindered, but in turn, it is readily executable.

Procedures Law for Emergency Situations or Events (Law No. 76-2000)

Procedures Law for Emergency Situation or Events, Law No. 76 of May 5, 2000, exempts government agencies, public corporations, and instrumentalities involved in the processing of permits, endorse ments, consultations, and / or certifications that may be related to projects that arise as a consequence of states of emergency declared by Executive Orders by the Governor of Puerto Rico or the President of the United States of America, of the compliance with terms and procedures established in the "Organic Act of the Puerto Rico Planning Board", Act No. 75 of June 24, 1975, as amended; the "Puerto Rico Permits Process Reform Law," Law No. 161 of December 1, 2009, as amended; the "Puerto Rico Autonomous Municipalities Law," Law No. 81 of August 30, 1991, as amended; and the "Uniform Administrative Procedure Law of the Government of Puerto Rico" Law No. 38 of June 30, 2017, as amended.

This law also establishes special provisions to adopts the procedure to attend emergency situations or events that require the performance of works, projects, or programs that do not require the issuance of permits, endorsements, consultations, and/or certifications; empowers the Governor to promulgate, amend, revoke regulations and orders, and terminate or resolve covenants, contracts or part thereof during the state of emergency; establishes the term of validity of the executive orders issued under this Law; enables different government agencies to expedite the procedures established in the aforementioned laws; and provides for judicial review. It is important to highlight that PROMESA establishes that any critical project, as defined in Title V Sec. 501, must be expedited, and streamed according to the provisions of this law, Act 76-2000.

Joint Operational Catastrophic Incident Plan of Puerto Rico (JOCIP).

The Joint Operational Catastrophic Incident Plan of Puerto Rico (JOCIP), approved in June 2019, was developed in the coordination of federal, state, local, and private sector committees. The JOCIP planning team was comprised of the Puerto Rico Department of Public Safety Emergency Management Bureau (PREMB), US Department of Homeland Security, FEMA, GPR state primary agencies, local governments, and critical infrastructure private sector representatives.

The JOCIP was developed through several planning phases that included in-depth research and study consisting of critical analysis of Hurricane Maria's After-Action Report; lessons learned and best practices from State Agencies; input from Federal Agencies such as FEMA, US Department of Defense (DOD), US Coast Guard (USCG), US Department of Health and Human Services (HHS), collection of empirical data, development of quantitative statistics, surveys, and risk analysis evaluations; over 200 interviews with representatives of the public and private sectors; and the identification of possible limitations and contingencies.

During the process, four workshops were held with representatives from public and private-sector organizations as well as non-governmental organizations. These workshops had an attendance of over 350 people and the participation of FEMA representatives of several "Emergency Support Functions," interagency coordinators from 30 State Agencies, and representatives of the private critical infrastructure sectors. The JOCIP is the first emergency plan in the history of Puerto Rico that has been developed with the direct participation of all sectors of our society, including professional, governmental, non-governmental, municipal, state, and federal organizations in a synchronized manner.

For the first time, the new JOCIP was designed following FEMA's Community Lifelines Implementation Toolkit Version 1.0, February 2019; the Homeland Security Presidential Directive #5 National Incident Management System (NIMS); the National Response Framework, Third Edition, June 2016; FEMA's Comprehensive Preparedness Guide 201 - Threat and Hazard Identification and Risk Assessment (THIRA) Third Edition, FEMA's Comprehensive Preparedness Guide 101 Developing and Maintaining Emergency Operations Plan (CPG101) Second Edition 2010; the National Fire Protection Association-Standard 1600-Standard on Disaster/Emergency Management and Business Continuity Programs; and other guidelines and standards.

Under the authorities conferred under PR Public Law 20-2017, the Secretary of the PR Department of Public Safety requires the Commissioner of PREMB to maintain this Plan in collaboration with the other State and Federal Agencies. This plan will be updated as needed within a one-year period.

Puerto Rico Planning Board (PRPB).

The PRPB was created by the "Organic Act of the Planning Board of Puerto Rico," Public Law 75 of June 24, 1975, as amended. This law created the PRPB; it defines its purpose, powers, organization, and interactions with other government bodies.

The main objective of this law is to guide the integral development of Puerto Rico in a coordinated, adequate, and economical way. The integral development must be in accordance with current and future social needs and human, environmental, physical, and economic resources. The needs and resources should promote health, safety, order, coexistence, prosperity, defense, culture, economic solidity, and the general well-being of current and future inhabitants in the best way. These include efficiency, economy, and well-being in the development process, in the distribution of population, in the use of land and other natural resources, and in public improvements that tend to create favorable conditions for society to achieve a full developed.

PRPB also has maps (i.e., land-use zoning maps) and interactive tools pertaining to land use suitability classification. Their resources include FEMA flood maps. Both instrumentalities can inform risk mapping, which is important for prioritizing mitigation strategies and prevention tactics in disaster management and emergencies. See also Joint Regulations for Evaluation and Issuance of Permits (2015), described below.

--PROMESA directs the PRPB to decide within a 60-day timeframe, regarding any “critical project,” as defined by PROMESA, that may affect the implementation of Land-Use Plans, as defined by Puerto Rico Act 550-2004. If PRPB determines that the project is inconsistent with relevant land use plans, then the project will be deemed ineligible for critical project designation under PROMESA.

Puerto Rico Land Use Plan (PUT).

The Law for the Use of Lands Plan of the Government, Law No. 550 of 2004, as amended, establishes the public policy to be followed to conserve and take advantage of natural resources for the benefit of the community, and in the same way preserve buildings and places of historical value. Article 3 allows the creation of an office of the Land Use Plan to the Puerto Rico Planning Board. Articles 6 to 10 provide the substantive and procedural requirements to create the Land Use Plan (Plan de Uso de Terreno “PUT,” in Spanish). The procedures for the inventory of resources are outlined in Article 11 and, Article 16 establishes the areas of the perpetual reserve. Article 17 sets forth the need for a special plan for the Municipalities of Vieques and Culebra. It also raises other provisions on Special Zoning Regulations that must be considered.

The PUT was approved by the Puerto Rico Planning Board, and it was effective starting November 19, 2015. This planning instrument establishes a territorial model for Puerto Rico and land management guidelines with urban and environmental references for the sustainable development of the country. The PUT provides for:

- Evaluation of the land according to its patrimonial, ecological, agricultural, landscape, rural, and urban value.
- Improvement of the coordination of planning and development efforts made by State agencies, public corporations, and municipalities.
- Conservation and promotion of at least 600,000 acres (cuerdas) with agricultural value.
- Provision of alternatives to accommodate housing needs and new developments, without negatively impacting or compromising agricultural soils, natural systems, watersheds, aquifers, heritage values, and landscapes.
- Promoting that citizens inhabit safe areas and that the necessary primary infrastructures are out of risk.

The PUT is aligned with the mitigation actions established in the 2016 PRSNHMP. In addition to

Regulation on Lotification and Development / “Reglamento de Lotificación y Urbanización”.

serving, conserving, and protecting the management of natural resources, the PUT proposes resilient planning and development in which the human habitat and infrastructure are protected from the risks associated with Regulation on Lotification and Development / "Reglamento de Lotificación y Urbanización".

The Regulation on Lotification and Development approved on January 27, 2016, (Planning Regulation No. 34) is proper for the mitigation of hazards by establishing the guides, controls, and coordination between the developer and the entities responsible for the infrastructure necessary for the proposed use, from the earliest stages of permitting.

Regulation on Special Flood Risk Areas / "Reglamento sobre Áreas Especiales de Riesgo a Inundación".

The Regulation on Special Flood Risk (Planning Regulation No. 13), as amended, establishes security measures to regulate buildings and land development in areas declared to be at risk of flooding. Regulation No. 13 has, among others, the following purposes:

- Protect human life and health.
- Reduce the need to use public funds for flood control work and mitigation plans.
- Reduce the need for rescue and relief efforts associated with flooding.
- Avoid changes to the natural hydrology of floodable valleys to protect and conserve wetlands.

In addition to being the administrator of the Regulation on Special Flood Risk Areas, the Planning Board is the Coordinating Agency for the National Flood Insurance Program and adopts the prepared Flood Insurance Rate Maps (FIRM) and approved by FEMA. The processes and definitions associated with the National Flood Insurance Program are part of Regulation No. 13. The implementation of Regulation No. 13 is essential since it directly addresses the danger of Flooding, which translates into the main tool for the mitigation of this hazard.

The provisions of this regulation establish the safety measures for: the control of buildings and land developments in areas declared susceptible to floods; to restrict or prohibit developments that could be hazardous to health, safety, and property, whenever they are prone to increase the flood, elevations or water velocity that could increase erosion. Also, to require that all flood-prone developments, including their service facilities, be protected against floods from the moment they are built; to control the filling, leveling, dredging, obstacles, and other types of development that could increase damages due to floods or surges; to prevent or regulate the building of barriers that could affect water flow or that could increase the risk of floods in other areas; and to discourage new developments, obstacles or substantial improvements, unless it has been shown that alternate locations, have been explored and proved not viable.

Law for the Reform of the Process of Permits of Puerto Rico, Law No. 161 of 2009, as amended.
The Law for the Reform of the Process of Permits of Puerto Rico, Law No. 161 of December 1, 2009, as amended, created a new integrated permit system for the Government of Puerto Rico; and the Office of Permit Management (known by its Spanish acronym as "OGPe") attached to the PRPB. This law establishes norms and objectives to manage the permit processes related to the development and use of land, through the new integrated permit system.

The purpose of the integrated permit system is to provide reliable and agile services to citizens, facilitated by a uniform, clear, and objective regulation that contributes to the progress and integral development of Puerto Rico.

Joint Regulations for Evaluation and Issuance of Permits related to Development and Land Use / "Reglamento Conjunto para la Evaluación y Expedición de Permisos Relacionados al Desarrollo y Uso de Terrenos.
The Joint Regulation purpose is to detail the integrated system of permits related to the development and use of land, in accordance with the public policy outlined in Law No. 161 of December 1, 2009, as amended, known as the Law for the Reform of the Process of Permits of Puerto Rico, through clear, objective, and uniform rules for the agile and effective handling of processes, consolidating in one place, in a logical order and without unnecessary duplication, all the rules applicable to them.

On November 29, 2010, a first Joint Regulation (hereinafter referred to as Joint Regulation 2010) was enacted, which was amended by Planning Board Resolution JP-RP31. On March 24, 2015, an Amended Joint Regulation was enacted (hereinafter referred to as Joint Regulation 2015). The Joint Regulation 2015 was contested in court (See: Héctor Morales Vargas v. Planning Board, KLRA 2015-00421). On December 22, 2016, the Appellate Court for the Government of Puerto Rico declared null the Joint Regulation 2015.

On June 7, 2019, another Joint Regulation was enacted via Planning Board Resolution JP-RP-38 (hereinafter referred to as Joint Regulation 2019). This Joint Regulation 2019 was also contested in court (See: Aequitas LLC. v. Planning Board, KLRA 2019-00413). On March 4, 2020, this Joint Regulation 2019 was declared null by the Appellate Court for the Government of Puerto Rico.

The effect of both Joint Regulation 2015 and Joint Regulation 2019 being declared null is that the regulation in force is Joint Regulation 2010. This Plan will be based on the Joint Regulation of 2010, which is the one that stands at this moment.

The Puerto Rico Permit Process Reform Act (Act No. 161 of 2009, as amended) establishes standards and objectives to manage, through an integrated system, permit processes related to the development and use of land. The Joint Regulation 2010 consolidates all the applicable rules for the development and use of the land of Puerto Rico.

To evaluate regulations related to emergency management and hazard mitigation, reference should be made to the following chapters of Joint Regulation 2010:

- **Chapter 12**: Processing of Permits, Recommendations, Consultations and / or Certifications during States of Emergency - Aligned with Law No. 76 of 2000, as amended, "Law on Procedures for Situations or Events of Emergencies."
- **Chapter 14**: Environmental Compliance Assessment - defines and establishes the environmental considerations to be evaluated when processing a final action or determination.

To preserve the areas with special zoning, refer to:

- **Chapter 31**: Special Zoning for the Reserves and Agricultural Corridors of Puerto Rico.
- **Chapter 32**: Zoning of the Coastal Zone and Access to the Beaches and Coasts of Puerto Rico
- **Chapter 33**: Special Zoning of Municipality of Culebra
- **Chapter 34**: Special Zoning of Parguera in the Municipality of Lajas
- **Chapter 35**: Special Zoning of the San Cristóbal Canyon in Aibonito and Barranquitas
- **Chapter 36**: Special Zoning for the Laguna Tortuguero Hydrographic Basin
- **Chapter 37**: Special Zoning for the Non-Urban Areas of the Municipalities Surrounding the Caribbean National Forest (El Yunque)

Volume VII of 2010 Joint Regulation contains conditions and recommendations on the electrical infrastructure, aqueducts, and sewers, and public roads, among others, and their evaluation requirements; OGPe may require more specific studies (e.g. soil studies) to analyze vulnerability to existing risks in infrastructure projects.

Ensuring the implementation of the 2010 Joint Regulation is essential for the PRSNHMP. This requires proper evaluation and analysis of infrastructure projects that can reduce vulnerability to risks.

National Flood Insurance Program (NFIP).

The National Flood Insurance Program (NFIP) was created by the United States Congress in 1968 to allow homeowners, renters, and business owners/tenants to purchase flood insurance with the support of the federal government. This program is administered by FEMA. Participating **c**ommunities agree to adopt and implement standards for land management in high-risk flood zones to reduce future flood damage, and in return, any property owner in a participating community can purchase flood insurance.

The goal of the NFIP is to provide flood protection to all homeowners, renters, and business owners, at a reasonable cost, throughout the country. Flood insurance covers direct physical damage and/or loss to property and/or contents because of a "flood." The NFIP defines a flood as excess water on land that is normally dry. The official definition used by the National Flood Insurance Program is a general and temporary condition of partial or complete flooding of two or more acres of land, usually dry or two or more properties arising from:

- Overflow of internal or marine waters.
- Unusual or rapid accumulation or spillage of surface water from any source.
- Mudslide.
- Collapse or subsidence of land along the shore of a lake or a similar body of water because of erosion or undermining caused by waves or water currents that exceed anticipated cyclic levels resulting in flooding as defined above.

The NFIP defines mudslide as a river of liquid and mud that flows on the surfaces of areas of land that are normally dry, such as when land is carried by a stream of water. The NFIP aims to mitigate flood damage by helping communities adopt and implement standards for land management in high-risk flood zones, regulate new construction in areas at high risk of flooding, and reduce future flood losses. The NFIP's operating expenses and flood insurance claims are not paid out of taxpayers' money, but through the premiums collected by flood insurance policies.

The information contained in the NFIP program further develops the understanding of vulnerability to flooding damaged properties and provides a greater likelihood of qualifying for Flood Control or Prevention Grants through the FEMA Flood Mitigation Assistance (FMA), Hazard Mitigation Grant Program (HMGP), CDBG-DR Housing, and Urban Development (HUD) programs and others.

To administering the Special Flood Hazard Areas Regulations, the PRPB is the Coordinating Agency for the National Flood Insurance Program (NFIP) as well as in charge for the adoption of the Flood Insurance Rate Maps (FIRM) prepared and approved by FEMA. The processes and definitions associated with the NFIP are part of Regulation No. 13. The implementation of Regulation No. 13 is fundamental since it directly addresses the danger of flooding, which translates into the main tool for the mitigation of this danger.

The GPR has a collection of FIRM maps that can be consulted to determine whether a property is located in a high-risk area or low to moderate-risk. The FIRMs refer to the official map developed and approved by FEMA and adopted by the Puerto Rico Planning Board to designate 100-year return flood risk zones (or 1% probability of occurrence). In addition, these maps serve as a tool for the management of special areas due to their susceptibility to flooding.

The Write Your Own (WYO) program began in 1983 as a partnership between insurance companies and FEMA. This agreement allows property and casualty insurance companies to write and service federal flood insurance policies under the company's name. What is unique about this type of policy is that all companies participating in the WYO program provide the same coverage and the rates must comply with the provisions and regulations concerning NFIP.

Communities adopt and enforce minimum NFIP standards for construction and development in areas designated as Special Flood Hazard Areas. As communities strive to achieve a higher level of safety and protection for their residents, in addition to the minimum NFIP standards, they have the option to participate in the NFIP Community Rating System (CRS). In this way, they can obtain reductions in the cost of flood insurance premiums. This is because the CRS recognizes the additional efforts of communities in (1) reducing flood damage to insurable property; (2) strengthening and supporting the provisions of the NFIP; and (3) promoting a comprehensive approach to flood valley management. These additional efforts provide community residents with greater safety, reduce property damage, increase community resilience, and foster a better quality of life for residents.

Floods are the most costly and common natural disasters and can occur at any time and in any location with extreme speed. Besides, the damage is not covered by a standard homeowner's insurance policy. In this regard, the Insurance Commissioner of Puerto Rico, in collaboration with the National Association of Insurance Commissioners and the Planning Board, developed educational literature with essential tips on these insurances so that people can prepare themselves in case of a flood. See **Appendix 4-2.**

The requirement that municipalities where communities are located adopt plans and projects to reduce flood damage. The insurance is sometimes included in a mortgage or loan on a property or business when the home or business is in a high flood risk area. In that case, it is recommended that you contact a mortgage or loan lender to find out if such insurance is included in the mortgage or loan. The insurance to work and the policy to cover flooded homes or personal property after a disaster must be obtained before the disaster occurs.

Four-Years Investment Program (PICA, for its Spanish acronyms).

The NFIP seeks to lessen the impact of flooding on public and private structures. If purchased after a disaster has occurred, the NFIP will not cover damage caused by the disaster.

In turn, the NFIP encourages owners or occupants of a home or business located in a community designated as a high, moderate, or low flood risk area to purchase the policy and thus mitigate the risk.

Four-Years Investment Program (PICA, for its Spanish acronyms).

The Four-Year Investment Program (PICA) document is prepared in compliance with the provisions of the Puerto Rico Planning Board, Act Number 75 of June 24, 1975, as amended. PICA integrates the investments to be made by the GPR through its various agencies and responds to the need to effectively allocate and distribute funds by directing them to the areas of the highest priority. It constitutes a short- and medium-term planning instrument aligned with the goals of the GPR and contributes to a sound and effective public administration.

This tool constitutes a short and medium-term planning instrument aligned with the provisions of the PROMESA Act ("Puerto Rico Oversight Management and Economic Stability Act") of 2016 and its Title VI, which provided for the alignment of a restructuring of negotiation and consensus between the GPR and the FOMB. In the financial planning and structuring exercise, it is imperative that Puerto Rico focus efforts so that investment in infrastructure can solve some of the most pressing needs while stimulating the growth of the Gross Domestic Product in the short term and supporting economic development in the long term; and that it will be feasible to increase the positive impact of infrastructure spending, among other things, by increasing the use of available federal funds.

Plan and Regulation for the Karst Special Planning Area (PRAPEC)

The elaboration of the Plan and Regulation of the Carso Special Planning Area (PRAPEC) is specified by virtue of the Law for the Protection and Conservation of the Karst Physiography of Puerto Rico, Law Number 292 of 1999. This Law aims to protect, preserve, and manage the karst physiography of Puerto Rico for the benefit of this and future generations. The Karst Physiography is in the north of Puerto Rico, as a continuous strip, in the south as a discontinuous strip, the islands of Mona, Monito, Caja de Muertos, and isolated outcrops in other parts of the island.

The Act 292 of 1999 orders the Secretary of the Department of Natural and Environmental Resources (DRNA for its Spanish Acronym) to define by study the karst physiography area. DNER produced the Carso Study in 2008 and stated what part of the Carso Restricted Area, also known as the Carso Restricted Special Planning

Area, further identifying, and delimiting the Karst Physiography is. Law 292 of 1999 also directs Puerto Rico's Planning Board to qualify these areas. It further empowers the Secretary of the DRNA to adopt rules and regulations that are necessary for the fulfillment of this responsibility, to issue orders, hold investigative and adjudicative hearings and impose the corresponding administrative fines for the violation of its provisions.

PRAPEC serves as a planning tool for the protection and conservation of the land, both in the Carso Special Restricted Planning Area (PRAPEC), and in the Special Planning of the Karst Zone (PRAPEC-ZC) through the creation of two Overlapping Districts of Special Qualification. Within the Carso Restricted Area, topographic features of a particular surface and underground expression have been developed. These terrains are distinguished by geology composed of sedimentary rocks, mainly limestone, where infiltration of runoff and underground drainage predominate. For this reason, it constitutes the largest groundwater recharge system for the supply, both underground bodies or aquifers, as well as its outcropping on the surface in the form of springs, wetlands, lagoons, streams, and rivers. Similarly, within the lands that comprise the APE-RC, unique ecosystems with a great diversity of flora and fauna species are located.

PRAPEC is based on / or rests on Law No. 267 of 2004, known as the Puerto Rico Sustainable Development Public Policy Act. Its goal is to: "Maintain and protect the environment by promoting the conservation, preservation and judicious use of natural, environmental, historical and cultural resources and recognizing that they present a variety and a wealth of options for our development and an opportunity to promote integral and sustainable development for all geographic sectors distributed throughout the island." However, the area is often exposed to damages, destructions, or degradation that directly affects the key ecological attributes characteristic of conservation objects (be they species, natural communities, or ecological systems, in this case, the karst). Resource demands can threaten the structure, the operation, the viability, and the key ecological attributes. The sources of demand are unsustainable human activities generated by pressures on the object of conservation. Natural disturbances (hurricanes, droughts, etc.) are part of the dynamics of ecosystems and, in principle, do not constitute sources of burden. However, when combined with human activities or unsustainable uses, such disturbances have catastrophic effects, making them a source of pressure.

The identification of pressures and their origin in the APE-RC provides better information for understanding not only the problems, threats, and limitations that affect objects in the conservation of the restricted area, but the reason for their existence. The importance of this type of diagnosis is to identify where it is necessary to establish conservation actions and where pressures on the object of conservation. These include but are not limited to:
Habitat loss.

- Habitat loss.
- Habitat fragmentation and reduced connectivity.
- Loss of biodiversity.
- Loss of ecological function.
- Loss of natural and landscape values.
- Disturbance to rare threatened, or endangered species.
- Incidence of pests and diseases in components of the flora.
- Detection of exotic and invasive alien species.
- Incidence of intentional or spontaneous forest fires.
- Deforestation.
- Reduction in forest cover.
- Changes in composition, coverage, and structure of ecosystems.
- Degradation in water quality.
- Erosion of the terrain.
- Presence of septic tanks.
- Salt intrusion, aquifer contamination.
- A decrease in aquifer recharge.
- Clandestine landfills.
- Extraction of the earth's crust: Quarries.
- Areas developed outside the scope of urban expansion.
- Incompatible uses such as mechanical workshops (sheet metal, paint, tires)
- Junkers and clandestine dumps, among others.
- Agricultural activities with environmentally harmful operating practices.
- Communities with the absence of sanitary sewerage and / or aqueducts.
- Urban run off.
- Removal of the Earth's crust.
- Landslides are associated with existing developments.
- The collapse of sinks due to abuse in the use of these for stormwater systems.
- Presence of structures on sinks.
- Industries with harmful practices for the karst resource.

Landslides, subsidence, and collapse of land are geological hazards recognized in the Puerto Rican Physiographic Map. There are also other geological and environmental risks of great importance in this physiography related to the hydrological system. These include:

- Cesspools and sewers as the main points of pluvial discharge in multiple communities located in the karst of Puerto Rico. Their catchment and infiltration capacity can be affected to different degrees due to various factors: temporary elevation of the local water table, obstruction of the discharge points towards the subsoil, reduction of the catchment area of the sump, and the design of new construction projects.
- The contamination with solid and liquid wastes that compromises the quality of water of the water supplies in the aquifers, an environmental problem that cannot be controlled after the infiltration of contaminants into the hydrological system in the subsoil.
- The diversion and obstruction of springs that contribute to the main rivers that flow through the Karst Physiography markedly decreases the flow of surface rivers.
- The extraction of wells that cause the collapse of land due to the decrease in the water table. This phenomenon must be considered when granting water extraction permits in the Puerto Rico Karst Physiography.
- The loss of reservoir water supplies due to the limestone rock dissolution processes that underlie it is a phenomenon that can potentially occur.

Furthermore, **chapter 7** of PRAPEC also provides to Municipalities included in the APE-RC are with management strategies that are within their reach and within their competence in the Territorial Plans. It also delineates plans and programs that pertain to areas with a special designation within the APE-RC that may be prone to risks that need to be considered when developing mitigation strategies.

Plan for the Conservation of Sensitive Areas for Adjuntas and Adjacent Municipalities, 2004 (PCAS)

The Plan for the Conservation of Sensitive Areas for Adjuntas and Adjacent Municipalities contains intervention strategies in terms of their aesthetic, cultural and historical value, considered to be an important source for Puerto Rico's economic growth. The document contains intervention strategies for these areas while establishing the uses in them. The purpose is to harmonize preservation and conservation with economic and social activities. The criteria considered for the delimitation of these sensitive areas are flora and fauna, resource tolerance level, watersheds, flood zones, existing communities, special planning zones, agricultural land, water bodies (rivers, lakes), scenic routes, biological corridors, and forests.

This plan is an important tool that contributes to the analysis of risks and vulnerabilities in the context of the damage caused by the hurricanes in 2017 and the earthquakes of 2020 for the central/southwestern area of Puerto Rico.

Office of Permit Management (OGPe, for its Spanish acronyms).

Puerto Rico Building Codes 2018.

The first edition of Puerto Rico Building Codes, known as the 2011 Puerto Rico Building Code, was compiled, and adopted in 2011 when the Permit Management Office (known by its Spanish acronym "OGPe") formally established, by Administrative Order 2011-16, the Building Codes Committee. It comprised of representatives

from the Puerto Rico Building Council and Government Regulatory Agencies, to review and implement a transition from the current 1997 Uniform Building Code to the ICC's International Code® family (I-Codes® 2009). The amendments to the ICC family of codes (I-Codes® 2009) and the original 2009 code composed the 2011 Puerto Rico Building Code.

For the second edition of the codes, Administrative Order 2017-11 formally established the Building Codes Committee, comprised of representatives from the Puerto Rico Building Council and the Government Regulatory Agencies. The Committee was responsible for the review and transition to the 2018 edition, with the International Pool and Spa Code. The intention was to publish a complete set of codes under the name of Puerto Rico that would incorporate each of the ten adopted ICC codes, from now on referred to as the 2018 Puerto Rico Codes® (PR-Codes® 2018).

The OGPe, attached to the PRPB, approved a regulation called the Puerto Rico Building Code on November 15, 2018. The provisions in this regulation are related to final determinations and permits for construction and land-use projects and certifications in Puerto Rico, including licenses, permits and/or certifications regulated by the OGPe.

The Building Codes of Puerto Rico adopted ten (10) of the International Council of Code 2018 adapted to the laws and regulations of Puerto Rico and the peculiarities of construction. The codes include:

- Puerto Rico 2018 Building Code, as amended by the 2018 International Building Code® (IBC).
- Puerto Rico 2018 Residential Code, as amended by the 2018 International Residential Code® (IRC).
- Puerto Rico Mechanical Code 2018, as amended from 2018 International Mechanical Code® (IMC).
- Puerto Rico Plumbing Code 2018, as amended from 2018 International Plumbing Code® (IPC).
- Puerto Rico Fire Code 2018, as amended by the International Fire Code 2018 (IFC)
- Puerto Rico Fuel and Gas Code 2018, as amended by the International Fuel and Gas Code 2018 (IFGC).
- Puerto Rico Energy Conservation Code 2018, as amended from the International Energy Conservation Code® (IECC) 2018.

- Puerto Rico Existing Building Code 2018, as amended by the 2018 International Existing Building Code® (IEBC).
- Private Wastewater Disposal Code of Puerto Rico 2018, as amended by the 2018 International Private Wastewater Disposal Code® (IPSDC).
- Puerto Rico's Swimming Pools and Spas Code 2018, as amended by the International Swimming Pools and Spas Code 2018 (ISPSC).
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The objective of the Puerto Rico Codes is to meet these needs through regulations that safeguard public health and safety in all communities. They include design standards that seek to ensure the health and safety of all construction and/or occupation in Puerto Rico by having hazard resistant provisions that present parameters for safer construction.

A "grace period" was established for this purpose for three (3) months, in which case proponents submitted construction documents that complied with the 2011 ICPRCP of this Code. All new projects submitted to the OGPe-DDEC after February 15, 2019, were required to meet all requirements of the Puerto Rico 2018 Codes, with the following exceptions: federally funded projects; priority facilities that can be used as shelters; anchored rooftop equipment; and projects in flood hazard zones.

Projects that were submitted before November 15, 2018, with a construction consultation in progress ("Consulta de Construcción"), a land consultation ("Consulta de Ubicación"), or a construction permit from the Puerto Rico Permit Management Office (OGPe-DDEC), or a permit office of a self-governing municipality, should be entitled to a twelve (12) month transition period under the 2011 Puerto Rico Construction Code.

The Puerto Rico 2018 Building Codes address the means of structural resistance of exit, sanitation, adequate lighting and ventilation, accessibility, energy conservation, and life safety with new and existing buildings, facilities, and systems. It also establishes the requirements, variations, and construction parameters to mitigate hazards (i.e., risks based on wind speed, flood hazards, earthquakes, tsunami hazards, among others) in different types of areas and structures. The micro-zone maps are provided with specific data on the characteristics of the various municipalities of Puerto Rico.

Regarding their maintenance, the codes will be reviewed and promulgated every three (3) years, starting from the date of their approval, as established in Law 161-2009, as amended. This three-year cycle will allow the incorporation of new construction methods and technologies into the codes. As in previous editions, the Puerto Rico Codes' content is subject to change through the CCI Code Development Cycles and the revisions established by law in Puerto Rico.

While the development procedure of the Puerto Rico Building Code Committee ensures the highest degree of care, its members and those who participate in this code's development do not accept any responsibility for compliance or non-compliance with the provisions. Only the governmental body that promulgates the code into law has that authority.

Department of Natural and Environmental Resources.

The Department of Natural and Environmental Resources (DNER) is an “umbrella” public department that absorbs the Puerto Rico Environmental Quality Board (PREQB) and Solid Waste Authority (SWA). This agency oversees the implementation and formulation of public environmental policy and the protection and conservation of natural, environmental, and energy resources. They have the mission of protecting, conserving, and managing the country's natural and environmental resources in a balanced way, to guarantee future generations their enjoyment and to stimulate a better quality of life.

The DNER, through its components, is responsible for the development and implementation of programs for the conservation and management of water resources, flood control and maintenance of water bodies, forest resources, forests, coastal and marine resources, fisheries, wildlife, nature reserves, and wildlife refuges. In coordination with the Auxiliary Secretariat for Integral Planning, it is also responsible for the development and implementation of acquisition processes for the land of high ecological value and for land necessary for the development of flood control works.

Furthermore, DNER, through the Coastal Zone Division, is the leading agency for the implementation of the Coastal Zone Management Program (PMZC, Spanish Acronym). This task is performed in close coordination with the PRPB, the government agency responsible for administering the Federal Program Compatibility Certification Process. Other entities such as the EQB, OGPe, Department of Agriculture, the Institute of Puerto Rican Culture, as well as the coastal municipalities, have responsibilities for managing the coast and its marine and coastal resources.

In addition, the DNER Organic Act, Law 23 of 1972, conferred to the DNER Secretary the duty to "exercise surveillance and conservation of the territorial waters, the submerged lands under them and the maritime-terrestrial zone, grant franchises, permits and licenses of public nature for its use and exploitation, and establish by Regulation the rights to be paid for them."

Environmental Public Policy Act.

The Environmental Public Policy Act (Law No. 416 of September 22, 2004), administered and supervised by the Environmental Quality Board/DNER, declares as public policy to use "all means and practical measures, including technical and financial aid, for the purpose to encourage and promote general well-being, and ensure that natural systems are healthy and have the capacity to sustain life in all its forms, as well as a social and economic activity."

This Act describes the considerations that must be considered when evaluating a project and establishes the following four objectives for development in Puerto Rico: (1) the most effective protection of the environment and natural resources; (2) the most prudent and efficient use of natural resources for the benefit of all citizens; (3) social progress that recognizes the needs of all; and (4) the achievement and maintenance of high and stable levels of economic growth and jobs.

Use, Surveillance, Conservation and Administration of Territorial Waters, Submerged Lands Under These and the Terrestrial Maritime Zone Regulation, DNR Regulation No. 4860.

The Use, Surveillance, Conservation and Administration of Territorial Waters, Submerged Lands Under These and the Terrestrial Maritime Zone Regulation, DNR Regulation No. 4860 of December 29, 1992, was adopted in accordance with these standards. Through these Regulations, the necessary requirements are established using terrestrial, maritime public domain assets, the territorial waters, the submerged lands, and the terrestrial, maritime zone. To offer the best information available to practice the demarcation of the maritime-terrestrial zone, the DRNA has undertaken the development of the Official Reference System for the Demarcation of the Maritime-Terrestrial Zone (known as SRO-ZMT, for its Spanish Acronym). This Official Reference System aims to address threats to natural coastal systems, as well as public safety.

Law for the Conservation, Development, and Use of Puerto Rico's Water Resources (Law No. 136-1976) & the 2016 Comprehensive Water Resources Plan.

Law for the Conservation, Development, and Use of Puerto Rico's Water Resources, Law No. 136 of June 3, 1976, as amended, (12 L.P.R.A. § 1115 ss), adopted the Water Law for Puerto Rico to declare the waters of Puerto Rico the heritage and wealth of the People of Puerto Rico. This law empowered the Secretary of the Department of Natural and Environmental Resources (DRNA) to develop, adopt, and maintain a Comprehensive Plan for Water Resources in consultation with the Water Resources Committee, appointed in turn by the Secretary.

In the 2016 Comprehensive Water Resources Plan, the DNER proposed two projects aimed at water reuse: 1) updating and adopting the Wastewater Reuse Plan of 2004; and 2) establishing a module whose purpose was to expose the benefits of wastewater use, quality standards.

Chapter 3 deals with the weather, and in particular, **Section 3.6.6**, with droughts. Droughts correspond to periods when humidity is substantially less than normal. The most impressive in Puerto Rico belong to a marked reduction in the rain during normally humid periods of the year.

The patterns in drought years are other than average; registered droughts in Puerto Rico normally start when there are no rains that fall between May and September. Droughts in Puerto Rico that affect water supplies usually start with the reduction in rainfall during the months of April and May. For this reason, the reservoirs do not fill before entering the summer, since it is a period of little rain.

According to data from 40 NOAA pluviometry stations around the Island, nine of the ten years with less rain occurred during the twentieth century beginning in 1950. However, because the severity of the drought varies from one part from the Island to another, that data does not reflect the severe effect that drought can have in any basin. That is, the severity of drought in a particular watershed can be worse still. Given the reduction in rain and water supplies that affected various regions of the country in 2014, a Protocol for Drought Management of Puerto Rico was developed and adopted.

Scientific and technical analysis (including hydrological, meteorological, and biological data), as well as weather forecasts and perspectives made by the Service Forecast Office National Meteorology Center, to identify the need to know the behavior of the water bodies in a long-term. For said reason, in 2014, the DRNA developed a tool to determine the hydrological condition of a basin compared to historical hydrological conditions. The Surface Water Monitoring Tool in the Main Basins of Puerto Rico uses the river flow data as the basis for at least 20 years of data as recorded at gauging stations operated by the USGS.

In addition to the information obtained by using the Surface Water Monitoring Tool in the Main Basins of Puerto Rico, the DRNA considers the information presented by the Drought Monitor. This is a tool developed by the National Center for Drought Mitigation, where different federal agencies collaborate, including NOAA and USDA, with the University of Nebraska-Lincoln. The monitor includes different variables, among them: The Palmer index, the humidity models of soil, river flow, and standardized precipitation index, among other variables.

The Drought Monitor establishes five drought categories: atypical, moderate, severe, extreme, and exceptional. For each drought category, a series of impacts. The final product of the Monitor is a map published weekly, indicating the areas most affected by drought, its intensity, and event trends, whether short or long term, and the affected population. The use of this tool provides a better scientific understanding, facilitating the decision-making process regarding adequate management of water supply.

Puerto Rico Land Acquisition and Conservation Fund Act (Law No. 268-2003).

The Puerto Rico Land Acquisition and Conservation Fund Act (Law No. 268 of September 5, 2003) declares and reiterates that the public policy of the Government of Puerto Rico is to promote sustainable development by ensuring the conservation of land of high ecological value. The law establishes and implements mechanisms that allow the conservation of Puerto Rico's natural resources and, in turn, guarantee the growth of the island in a planned manner. It considers the importance of maintaining a clear strategy regarding the protection and conservation of land that has ecological value, to contribute to promoting other sectors of the economy such as agriculture and tourism, since such protection will allow the protection of water, air, and land resources that are so necessary for economic development.

The law established a fund under the Treasury Department named "Puerto Rico Land Acquisition and Conservation Fund" to be administered by the Department of Natural and Environmental Resources. It is important to emphasize that this is a parallel mechanism to other governmental and non-governmental initiatives that exist on the island. Some of these initiatives are the Natural Heritage Program of the Department of Natural and Environmental Resources, the Conservation Trust, and the Karso Citizens. These initiatives can purchase environmentally sensitive land to be preserved, conserved, and / or protected from excessive development.

Regulation of the coastal zone is crucial due to the development pressures that these lands receive and the effects of coastal erosion that expose the infrastructure and structures adjacent to these natural systems to greater and more frequent episodes of flooding and possible material losses. Existing regulations allow conserving the resources associated with the coastal zone, protecting the industries or services that develop in them, and mitigating or eliminating their vulnerability.

San Juan Ecological Corridor Designation Act. (Law No. 206 of 2003).

The San Juan Ecological Corridor Designation Act, (Law No. 206 of August 28, 2003), name various lands as the San Juan Ecological Corridor; prohibit the granting of construction permits in that area;

order the Department of Natural and Environmental Resources to acquire all the land that these farms comprise; empower the Secretary of the DNER to enter into agreements with other governmental, community and private entities; order the Secretary of the Department of Natural Resources to appoint a Special Commission to write a Conservation and Management Plan for this area.

In tune with the objective to preserve ecosystems, the Government of Puerto Rico identified an area of approximately one thousand (1,000) cuerdas, part of the only green remnant of San Juan, which include forests, swamps, beaches, coral communities, and a bioluminescent lagoon; and constitute invaluable natural resources which are a source of refuge and food for wildlife, stabilize the effect on erosion, the water levels of rivers and streams, the relative humidity, and the temperature of the city.

Puerto Rico's Climate Change Mitigation, Adaptation, and Resilience Act; Law 33-2019.

On May 22, 2019, Puerto Rico's Climate Change Mitigation, Adaptation, and Resilience Act, Law No. 33 of May 22, 2019, as amended, was passed. This law establishes the public policy of the Government of Puerto Rico regarding climate change and the processes of mitigation, adaptation, and resilience by sector. In addition, it orders the establishment of an inventory of greenhouse gas emissions; a Climate Change Mitigation, Adaptation and Resilience Plan is approved; a Committee of Experts and Advisers on Climate Change is set up; and a Joint Commission is set up to mitigate, adapt and resilience to climate change in the Legislative Assembly.

Through this legislation, it is recognized that a variety of studies have been conducted in Puerto Rico on the adverse effects of not addressing climate change on the island (Puerto Rico's Climate State: Vulnerability Assessment Socio-ecological of Puerto Rico in a Changing Climate (2013); Path to Resilience; Puerto Rico Climate Change Adaptation Strategies Guide (NOAA, 2015); Daytime temperature range in Puerto Rico 1950-2014 (Méndez Tejada, 2015); Energy Resource Catalog of the University of Puerto Rico (Known as INESI); Climate Change Adaptation Plan (DRNA, 2016); however, there is no coordinated plan that integrates the different sectors and directs work to assess that the proposed metrics and objectives are effectively achieved.

This legislation seeks to establish, among other things, concrete metrics, objectives, and guides to develop a Climate Change Mitigation, Adaptation, and Resilience Plan, to be developed under the recommendation of a group of experts to form the Committee of Experts and Advisers on Climate Change. The Act establishes the means to establish tools to achieve clear parameters and targets in relation to energy efficiency and the new Renewable Energy Portfolio under the Puerto Rico Public Energy Policy Act and Law 82-2010. Finally, it contains initiatives and recommendations resulting from the efforts made by the Multi-sectorial Working Group on Climate Change created through Executive Order 2018-45.

Puerto Rico Climate Change Council 2015 – Road to Resiliency: Guide on Adaptation Strategies for Climate Change[38]

The main objective of the Guide to Strategies for Adaptation to Climate Change in Puerto Rico is to provide mitigation strategies and increase the resilience of different entities to implement preventive and corrective actions on the island. Topics such as adaptation concepts (adaptation actions and strategies) and steps to develop a climate change adaptation plan are presented. The guide is then divided into four parts, which are adaptation strategies for national level, municipal level, community level, and household level.

The national adaptation level includes concepts such as integration of decisions into the functioning of society, the role of science in adaptation plans, the importance of communication, national support for local communities, the importance of the national context, and case studies. It also contains adaptation options for critical infrastructure, for coastal communities, for tourism and recreation, for economic development, and for biodiversity. At the municipal level, topics such as perspectives of coastal municipalities, suggestions for municipalities regarding the effects of climate change, preparedness measures, a table on possible actions for municipal functions, and municipal administration for natural resources, support to the local economy through adaptation of the agricultural sector, how to manage financial constraints, and sources of financing.

At the community level, the topics are adaptation strategies, adaptation options for green infrastructure, low-impact development, reduction of urban heat islands, construction and development management, zoning, redevelopment restrictions, conservation easements, community compact design, tourism, and economic development, and biodiversity. Finally, at the household level, is about: the home as the main engine of adaptation, ensuring access to food and safe shelter, preparing houses for climate change, protection against floods, against droughts, ways of refreshing the house, case studies, protecting schools and table summarizing all adaptation options at the household level.

Phase I - Sea Level Rise Adaptation Review of Design Criteria for Coastal Infrastructure in Puerto Rico, 2015[39]

The Phase I- Sea Level Rise Adaptation Review of Design Criteria for Coastal Infrastructure in Puerto Rico aims to prepare and manage the impacts associated with the sea-level rise on coastal communities. These

[38]Puerto Rico Climate Change Council (2015). Ruta hacia la Resiliencia: Guías de Estrategias para la Adaptación a los Cambios Climáticos. Departamento de Recursos Naturales y Ambientales, Programa de Manejo de la Zona Costanera; Ernesto L. Diaz, Kasey R. Jacobs y Vanessa Marrero, editores.

[39]Tetra Tech (2015). Phase I - Sea Level Rise Adaptation Review of Design Criteria for Coastal Infrastructure in Puerto Rico. Departamento de Recursos Naturales y Ambientales, Programa de Manejo de la Zona Costanera; Ernesto L. Diaz editor.

adaptation measures will be useful to develop technical guidelines and adaptation tools that can be implemented at various levels and across the different agencies.

The topics included in the document are initial assessment of building codes on sea-level rise, critical Infrastructure and Adaptation Tools, Summary of Desktop Study on North American Coastal States SLR Adaptation Programs, Puerto Rico's Agencies Response to OE-2013-016, Status Summary of Puerto Rico's SLR Adaptation Strategy, Conclusions and Recommendations. Also, includes references, appendixes, list of tables, and list of figures.

The section of "Initial Assessment of Building Codes on Sea Level Rise" assesses the existing building codes and design criteria currently utilized in governmental entities in Puerto Rico for better adaptations. The agencies were consulted to protect their existing infrastructure to sea level rise and to assess the adaptation strategies they are developing to accommodate for sea level rise. The main public agencies that are mentioned are: Puerto Rico Department of Transportation (PRDOT), Puerto Rico Ports Authority (PRPA), Puerto Rico Energy Power Authority (PREPA) and Puerto Rico Aqueduct and Sewer Authority (PRASA).

On the other hand, the section named "Critical Infrastructure and Adaptation Tools" it is useful for develop strategies of mitigation in the future. The guide presents a background of vulnerable Infrastructure and Coastal Communities, Adaptation Approach (Steps-Protect, Accommodate, Retreat and Avoid), Basis for Sea Level Rise Adaptation and multiples Adaptation Tools (Planning Tools, Regulatory Tools, Land Use Tools, Structural Tools and Non-Structural Tools). These instruments are exposed to be implemented in different agencies, communities, and municipalities. The last sections are about: Coastal Management Programs, Summary of Agencies Outreach, Status Summary of Puerto Rico's SLR Adaptation Strategy, Conclusions and Recommendations.

Financial Guide for Coastal Resiliency, 2018[40].

The Financial Guide for Coastal Resiliency was designed for municipalities to learn about and access different federal grants and mobilize their resources to strengthen coastal areas under their jurisdiction. It is a facilitation tool to finance and implement coastal resilience measures/projects on the island. The guide is divided into three parts, the topics are ways to achieve recovery, sources of funds and post-recovery financing strategies and best practices and innovative approaches in post-disaster financing.

[40] Tetra Tech. (2019). Guía de Financiamiento para la resiliencia costera: Una herramienta para que los municipios de Puerto Rico se recuperen de los impactos de los huracanes Irma y María. San Juan: Departamento de Recursos Naturales y Ambientales Programa de Manejo de Zonas Costeras (PMZC) para Puerto Rico, Administración Nacional Oceánica y Atmosférica de Estados Unidos (NOAA), 2-1.

The Section on "coastal resilience" presents classifications that should be addressed with priority for effective which are: coastal management and restoration, infrastructure in municipalities, and natural resource management. In the section on “the road to recovery” is about five steps to follow: 1) That people can return to their homes, 2) catch the perishable data, 3) Manage the post-disaster debris, 4) Establish a comprehensive recovery program, and 5) Create plans to support federal funding and long-term recovery.

In addition, the unit of “Funds and Strategies”, provides information about the background on federal disaster relief on the island since Hurricane Maria in 2017, a table on federal appropriations for disaster relief in Puerto Rico, federal agencies and non-profit entities that support coastal resilience. Also, includes municipal tools to generate income and innovative financing strategies. In the part of “Best practices and innovative post-disaster approaches” are mentioned initiatives such as the development of an action plan for federal CDBG-DR funds, mobile technologies, applications, one case study for a FEMA risk mitigation grant, checklist for general funding requests, and different examples of success.

Protocol for Drought Management in Puerto Rico (Protocol).

During the 2014-2016 drought and as a measure to document and have the government act in a coordinated manner, a guiding document was developed, entitled Protocol for Drought Management in Puerto Rico (Protocol). This first Protocol was prepared as an initial response to the 2014 drought, to guide interagency efforts to monitor and coordinate actions in the face of drought events. Droughts manifest themselves in different ways throughout the island, affecting some regions while others remain under humid or normal conditions. Of all the island's areas, the southern coastal sector is the most vulnerable due to its low rainfall and limited water reserves[41].

There are several types of drought, including meteorological, agricultural, and hydrological. One of the indicators of possible meteorological drought events for Puerto Rico is a significant rainfall reduction between May and November. These rains are essential for planting crops and the development of improved pastures for livestock, and the recharge of aquifers. One of the main effects of the agricultural drought is the deterioration or loss of animal deterioration or the reduction of crops, seriously affecting the agrarian community and generating large monetary losses. Hydrological drought manifests itself gradually. Depending on the level of severity of the surface and sub-surface components of the hydrological system, it can take months to recover once the rainy cycle begins since surface and sub-surface waters replenish very slowly.

[41] Comité Ejecutivo de Sequia (2015). Protocolo para el Manejo de Sequía en Puerto Rico., 4.

Puerto Rico Energy Power Authority (PREPA)

Puerto Rico's System Transformation Act.

The Puerto Rico's Electricity System Transformation Act, Law 120-2018, seeks to transform the energy system through Public-Private Alliances (Law 29-2009) to obtain a financially viable electricity system with a focus on consumer welfare. This law authorizes the modernization and adoption of an innovative model that is sustainable, with advanced technology and resilient to the onslaught of nature.

The statement of reasons indicates that the Puerto Rico Electric Power Authority (PREPA) lacks the conditions to offer an efficient and cost-reasonable service for residential, commercial, and industrial consumers given budgetary and financial precariousness. PREPA's infrastructure has not only deteriorated by the abandonment of the system but has been severely damaged by atmospheric effects further exacerbating and undermining the deteriorating condition of the electrical system. The United States Government federalized the recovery process of the electrical system and delegated it to the United States Army Corps of Engineers, to the extreme of being the determining voice in the purchase and distribution of equipment, materials, and supplies; and, in the allocation of tasks and areas to the reconstruction brigades. Furthermore, the public corporation had also been forced to take refuge in a bankruptcy process under Title III of PROMESA (See **Section 4.2.1**).

Puerto Rico Dam Safety State Program under Law 133 of 1986.

There are 37 dams that are classified as high risk due to the people that may be affected in case of a dam breach. These dams provide water for human consumption, irrigation, and power generation. Other dams are just for the purpose of inundation control. The state has the responsibility of protecting the life and property of the residents that reside downstream these water reservoirs.

Any water impoundment represents risks. These risks must be identified and monitored. It is the purpose of the Dam Safety State Program to monitor the dam's performance to preserve the life and property of the residents downstream.

To do so, the GPR established legislation to create the Puerto Rico Dam Safety State Program under Law 133. The purpose of this program is described in the following bullets:

- Carry out detailed and complete periodic inspections every three (3) years, setting an order of priorities to determine the safety conditions of the dams and reservoirs and to make assessments about the hydraulic and hydrologic capacity, the structural stability, and the sufficiency of the components and structures to minimize the risks for life and property and to make recommendations to the owners of the dams and reservoirs about the measures that should be taken to remedy any dangerous situation.

- Review and approve the plans and specifications to build, extend, modify, or remove any dam or reservoir if plans and specifications should be accompanied by studies, investigations, analysis, and designs facts that would allow the Unit to determine its safety.
- Carry periodical inspections during the construction, extensions, abandonment, or removal of a dam to ensure compliance with the plans and specifications it had approved.
- Issue notifications when necessary to require the owner or person in charge of the dams or reservoir to correct defects or unsafe conditions, to carry out the necessary work of conservation, to review the operational processes, or to take any other necessary action.
- Approve and issue the corresponding certification of approval and permission after completing the construction, extension, or modification of a dam or reservoir, if it has complied with the plans and specifications for its safety.
- Organize, verify, and approve the Emergency Action Plans for the dams in the program.
- Prepare and maintain a Risk-Based Inventory on the State Dams.
- Require and propose interim risk reduction measures to reduce the operation.
- of dams that do not meet the societal risk standards. Risk as defined by FEMA[42].
- Engage in Hydrological and Hydraulic Studies to verify the Spillway Capacity of dams.
- (Example Island Wide PMP).
- Organize and provide Dam Safety Training to owners.
- Organize and propose Dam Break exercises to owners.

Inspection and Regulation of Dams and Reservoirs. / PREPA Dam Safety Unit

Puerto Rico has no natural lakes and reservoirs constitute the main source of drinking water for the island's over 3 million inhabitants. There are 37 main reservoirs on the Island owned by the Government of Puerto Rico, in addition to several smaller private reservoirs. Among these 37 public reservoirs, 21 are considered larger from the point of view of volume and diversity of uses. Law Number 133 of 1986, creates the State Program for Inspection and Regulation of Dams and Reservoirs with the purpose of maintaining, conserving, inspecting, and ensuring the safety of dams and reservoirs in Puerto Rico.

The program is administered by the PREPA through its Dams and Hydrology Section, known as the Inspection and Regulation Unit for the Safety of Dams and Reservoirs (IRUSDR). The IRUSDR has the duty and power to:

[42]Federal Emergency Management Agency (2015). Federal Guidelines for Dam Safety Risk Assessment. FEMA P-1025.

- Adopt a program plan for the operation, conservation, maintenance and inspection of all private and public dams and reservoirs in which they include mitigation responses when the occurrence of natural phenomena that may affect the structures and increase the risk of damage to life and property.
- Maintain an up-to-date inventory of dams and reservoirs in Puerto Rico.
- Carry out periodic, detailed, and complete inspections, at least every three (3) years, establishing an order of priority to determine the safety conditions of dams and reservoirs, and make evaluations of hydraulic and hydrological capacity, stability structural and the adequacy of components and structures to minimize risks to life and property and make recommendations to the owners of dams and reservoirs on the measures to be taken to remedy any dangerous situation.
- Review and approve the plans and specifications to build, expand, modify, or remove any dam or reservoir; Provided, That the plans and specifications must be accompanied by the studies, investigations, analyzes and design data that allow the Unit to determine safety.
- Carry out periodic inspections during the construction, expansion, abandonment, or removal of a dam to ensure compliance with the plans and specifications that it approved.
- Issue notifications when necessary to require the owner or person in charge of the dam or reservoir to correct defects or unsafe conditions, carry out the necessary conservation work, review the operational processes or to take any other necessary action.
- Approve and issue the corresponding approval and permit certification, after completing the construction, expansion or modification of a dam or reservoir, if the plans and specifications for their safety have been complied with.

Law Number 207 of 2002, amends articles 4, 6 and 8 of Law No. 133 of 1986: Committee for Supervision and Evaluation of the State Program for Inspection and Regulation of Dams and Reservoirs. These amendments provide that the Committee for Supervision and Evaluation of the State Program for Inspection and Regulation of Dams and Reservoirs may be composed of representatives of the respective agencies, who have been delegated the power to act on behalf of the respective agencies and establish a new way of calculating the contribution that corresponds to pay to the PREPA by each entity or person who owns a reservoir or dam, and for other purposes.

Also, Article 8 of Law No. 207, establishes a that the Committee will promulgate a regulation to establish the duties and obligations of the owners of dams and reservoirs that guarantee their conservation, and to determine the way in which the contribution corresponding to each public agency, person or private entity will be calculated, based on the costs incurred by the Program and the size, material, age, and conditions of the retaining wall in each of the dams and reservoirs that receive the services provided by the Unit.

This Committee is represented by the Dam Safety Officer on the Interagency Emergency and Mitigation Committee, as mentioned in Chapter 2 of this Plan.

During the update of this Plan, the Dam Safety Unit have provided information requested by the team working the plan review. From Dam Break Flooding Maps to other studies related to seismic activity of Puerto Rico Geology, in complement to participation in the Mitigation Committee meeting on September 25, 2020.

Besides from the Dam Safety Unit, it is the Dam Safety Regulation division in which considerate three (3) types of dam hazards potentials as a methodology. The low hazards which is such dam that in case of a dam break do not affect life or properties, significant hazard which in case of a dam break it only have economic effects but do not affect the life of residents. The high Hazards which are dams that in case of a dam break have the potential of affecting the life of one or more residents from the flooding zone[43]. To determine which dam represents a higher risk than others DSU uses a risk approach as developed by the United States Bureau of Reclamation (USBR). (See attachment).

At the present, the biggest project to mitigate any potential effects or risk due to a dam break is the development of an Island Wide Early Warning System for every dam. For dams that are not within the dam Safety Guidelines such as Guajataca, Patillas and Guayabal the following is being done:

- Guajataca was assigned $560,000,000 for the permanent work to reduce risk to the public.
- Patillas is under FEMA 404 program for funding request. Now the USBR is working on plans and specifications for a full dam retrofit.
- Guayabal dam finish its Risk Analysis for a 30% alternative, we wait for the final Report and we are in coordination with the USBR to prepare an Agreement for the preparation of Plans and Specifications to solve the structural issue on the dam. No finding mechanism is being identified and the cost of this project is close to $150,000,000.

As part of the risk reduction process there is a process of studies, risk analysis, development of plans and specifications and the final implementation or construction process. As part of the HHPD program DSU identified a list of dams that do not met the satisfactory classification in the USACE Inventory of Dams.

From these inventories and being the first time, we participated in these grants, DSU were awarded $156,479, subject to the approval of this Plan. With the amount awarded DSU will be performing a

[43]Federal Emergency Management Agency (2015). Federal Guidelines for Dam Safety Risk Assessment. FEMA P-1025.

geotechnical investigation on Guayo Dam (in the Municipality of Adjuntas) which has a risk of a foundation failure driven by unfavorable jointing in the left abutment.

State and Municipal governments are responsible for the evacuation of the areas to be affected by flooding or a dam break. Owners provide an Emergency Action Plan to each municipality which provide the communication strategies within the owner authority to provide information in case of a situation. Each OMME's is responsible in prepare their action plan in case of a dam break and includes the Dam Owners Emergency Action Plan as part of their emergency operation.

Puerto Rico Aqueducts and Sewer Authority (PRASA).

Action Plan for Emergencies in the Carraizo Dam (PAE), Revision 2019

The Action Plan for Emergencies in the Carraizo Dam (by its Spanish acronym PAE), as revised in 2019, is a plan intended to guide Aqueduct and Sewer Authority (by its Spanish acronym PRASA) officials when abnormal conditions arise that could jeopardize the security of the Carraizo Dam, and which could lead to dangerous floods. It also includes the actions that must be carried out by PRASA officials and employees during an emergency that may put at risk of losing the life of persons and cause considerable damage both of economic and environmental nature.

The Carraizo Dam is located on the PR-175 Road, at kilometer 7.5 of Carraizo Ward in Trujillo Alto, Puerto Rico. Although the Carraizo dam is in good condition from a structural point of view, extraordinary circumstances may arise where the normal operation or stability of the dam is threatened, with the resulting risk of rupture.

The intent of the PAE is to assist emergency officials in saving lives, reducing damages to properties or structures, and minimizing environmental impact in the event of flooding caused by large dam discharges, dam failures, or other types of events that present dangerous conditions. Emergency events can occur in varying degrees of severity and anticipation. An emergency can develop gradually or suddenly. When it is gradually, there is ample response time. However, when it is sudden, quick response to the emergency is required. The PAE includes classifications of emergency events developed according to the severity of events as an "unusual situation," "situation in progress," or "imminent situation."

Extraordinary circumstances may include uncontrollable extreme flows entering the lake during high influx events such as a major atmospheric disturbance. In that case, preventive measures can be taken to significantly reduce the risk of an uncontrolled overflow. However, there are other circumstances that are not foreseeable, such as a rupture caused by a major earthquake. In such a case, prevention and control measures may be impossible; and that only possible measure to be taken is to alert public security agencies and the citizens living downstream of the dam.

The PAE will guide the dam's operations, supervisors, and PRASA's personnel to identify, monitor, respond to, and mitigate emergency situations. The PAE describes "what each one does, where, when and how" during an emergency, or an extraordinary occurrence that affects the dam. The PAE intends to interact with the emergency operation plans of other municipal, zone, state, and federal agencies to ensure that response actions are implemented effectively.

PRASA is the owner of the dam and is responsible for its safety, administration, operation, maintenance, repair, and rehabilitation. In an emergency, the PRASA is responsible for making internal and external notifications, implementing response and mitigation actions, and documenting all activities. The Municipalities of San Juan and Carolina, specifically Zones I and XII of the PREMB, and the state and federal authorities are responsible for beginning the sequence of alert calls, initiating, and coordinating the emergency operations, preventively removing the population at risk, and carrying out the actions that are necessary to guarantee the life and safety of the public.

Department of Economic Development and Commerce (DDEC).

Puerto Rico Energy Assurance Plan (EAP).

In 2019 the Governor of Puerto Rico, Hon. Wanda Vazquez Garced has assigned the Puerto Rico Energy Policy Program from the Department of Economic Development and Commerce (EPP-DDEC) to develop the Island's Energy Assurance Plan (EAP) under Act 17-2019. The DDEC-EPP strongly believes in the importance of pursuing better energy assurance planning to help contribute to the resiliency of the energy sector, including the electricity grid, by focusing on the entire energy supply system, which includes refining, storage, distribution of fossil and renewable fuels, and incorporation of new smart grid technologies. Further, the DDEC-EPP intends for this Energy Assurance Plan to be supportive with Energy Bureau and Homeland Security Managers, and all stakeholders, throughout Puerto Rico in their efforts to develop and maintain integrated and comprehensive all-hazard, all-threat emergency plans.

The EAP must reflect and address the unique lessons learned from recent hazards and threats that have faced Puerto Rico. Accordingly, the DDEC-EPP approached this effort with not only the obligation to meet federal requirements for emergency planning but also an interest in actively collaborating with local and state stakeholders in Puerto Rico, including the government-owned electric utility, wholesale fuel providers, consumer representatives, and other Island governmental agencies.

The DDEC-EPP has adopted most of those guidelines in coordination with local state plans to complete this assignment, according to the guidelines for the development of State Energy Assurance Plans developed by the National Association of State Energy Officials (NASEO). The objective of this Plan (approved on June 2020) is to establish these policies and procedures, based on a comprehensive approach that has been assumed to identify critical energy infrastructure assets; obtain, evaluate, and integrate existing emergency response plans; and ensure that going forward Puerto Rico's EAP meets new state objectives and guidelines after learning from Hurricane Maria, recent earthquakes, and health pandemic challenges of the 21st century.

EAP will become part of the Plan2Ops (P2O), a mobile and desktop application that automates any type of All-Hazard Emergency, Recovery, or Mitigation Plans. P2O will send Push Notifications that will include specific tasks, locations, instructions, forms, or images to all the stakeholders and government personnel that have a responsibility in the Plan. SP2O provides a dashboard that allows executives to see how efficiently each one of these plans are being implemented, providing full accountability and synchronization between users and stakeholders. The objective is to make sure all users are notified of their duties during all the implementation phases.

Department of Health.

Preparedness and Response Plan for COVID-19.
This plan describes the activities associated with preparedness and response to a public health emergency in Puerto Rico caused by the detection of COVID-19. Since this is a novel disease with a continuous change in the knowledge acquired about the disease, the activities described serve as a guide for decision-making and will be adapted to the cases and situations that arise. The planning envisaged in this document corresponds to the strategies and actions of the Department of Health of Puerto Rico in the face of this type of public health emergency. This planning will be supported by the individual but coordinated actions that fall under the responsibility of the other agencies and entities of the Government of Puerto Rico, federal agencies, non-profit organizations, and the private sector that take part in the response operations.

The Plan's purpose is to establish a frame of reference for public health, medical services, and mental health work together to reduce morbidity, mortality, and social and economic disruption associated with an outbreak of COVID-19. GPR's agencies and external organizations will share the document, which contains roles and which contains roles and responsibilities for the coordination activities listed in the Emergency Support Function - Public Health and Medical Services (ESF-8) for operations' response.

Red Sísmica de Puerto Rico.

Tsunami Ready Program and its implementation process (2005-2020).

To reduce the loss of lives and property and to protect livelihoods and economic prosperity, communities need to be ready to respond quickly and appropriately to this threat. To address this challenge, Puerto Rico has been implementing the Tsunami Ready® Program of the US National Weather Service (NWS) in 2005. In 2016 Puerto Rico was recognized as Tsunami Ready when all forty-six municipalities at risk had met the Mitigation, Preparedness and Response guidelines. The program's successful implementation requires a collaborative approach between residents, businesses and government officials, state emergency management officials, the NWS, the PRSN, and the broader science and academic community. Initial investments were made in tsunami hazard and evacuation maps, plans, procedures, and infrastructure. Thru Tsunami Ready, local communities are empowered to prepare and respond to tsunamis and other risks, as demonstrated in events such as Hurricane Maria.

While Tsunami Ready focuses on the tsunami threat, many actions also support readiness for other hazards like it was demonstrated in Hurricane Maria. Like its sister program, Storm Ready®, it can also be used as a model to empower communities to become resilient to all hazards. Complementary programs like Tsunami Ready Supporter, Tsunami Ready Champion, and Tsunami Ready Tier 2 help address some of the challenges of Tsunami Ready communities.

In Puerto Rico, tsunamis can arrive just minutes after an earthquake; it has happened before and can happen again. These devastating waves can reach the shore before official alerts are issued and disseminated. The 1918 Puerto Rico earthquake and tsunami and more recent catastrophic tsunamis in the Indian Ocean (2004) and the Pacific Ocean (Chile, 2010 and Japan, 2011) have highlighted the need for communities to respond. This requires identifying and mapping hazard areas, evacuation maps, plans and procedures are in place, hazard zones, evacuation routes, and assembly areas are clearly identified. The public is educated to recognize and understand natural and official alerts and know how to respond accordingly. Until mid-90's tsunamis were a "forgotten hazard" and while the scientific and public awareness of these events advanced at the turn of the century, when the 2004 devastating tsunami occurred in the Indian Ocean, Puerto Rico communities were almost as unprepared as those in the Indian Ocean. Its low frequency put it low on the priority list for actions.

Noting the gap in community readiness, the US National Weather Service (NWS) approached the Puerto Rico Seismic Network in 2005 to lead an effort to make Puerto Rico Tsunami Ready®.

The Tsunami Ready program established guidelines which have evolved over the years for a standard level of capability to mitigate, prepare for and respond to tsunamis and working with communities to help them meet the guidelines and ultimately become recognized as Tsunami Ready by the NWS.

The current guidelines were approved in 2016 and are divided into three categories of disaster risk reduction: Mitigation (MIT), Preparedness (PREP and Response (RESP)[44]. Recovery is included in Tier 2 Tsunami Ready which also addresses the challenges of difficult to evacuate areas. In terms of Mitigation, the program addresses the following guidelines:

- MIT-1 Have designated and mapped tsunami hazard zones.
- MIT-2 Include tsunami hazard and community vulnerability information in the community's FEMA-approved multi-hazard mitigation plan.
- MIT-3 Install signage, as needed, that identifies for example: (1) tsunami danger area and/or hazard zone (entering and leaving signs), evacuation routes, and assembly area; and (2) provides tsunami response education (go to high ground).

Within Puerto Rico, as for each of the US jurisdictions, there is a Tsunami Ready board. This board is responsible for verifying that the communities seeking recognition have met the thirteen guidelines. The board is chaired by the Warning Coordination Meteorologist of the NWS Forecast office of San Juan. The other members are representatives of the Puerto Rico Seismic Network, PREMB, and the NWS Caribbean Tsunami Warning Program.

4.2.2 Federal Standards and References Related to Hazard Mitigation.

Robert T. Stafford Disaster Relief and Emergency Assistance Act.

This legislation includes three sections directly related to mitigation activities. These are sections 404, 406, and 409. Section 404 provides funds for cost-effective mitigation activities that reduce potential damage from future disasters. These mitigation measures are identified in the natural hazard assessment and recommendations required by **Section 409**. **Section 406** is administered by FEMA. Funding is disaster-based requiring ten percent (10%) match for the project. Only damaged facilities and disaster declared areas participated in the Program so FEMA can prepare the applications. The mitigation work completed before FEMA funding approval is also eligible.

[44] (https://www.weather.gov/tsunamiready/guidelines)

Section 409 of the Act states as a requirement for receiving federal assistance that the territory that will receive the funds must make an analysis and evaluation of the natural hazards in the areas where the funds will be used. In addition, **Section 322** (Mitigation Planning) of the above-mentioned Act enacted through Section 104 of the Disaster Mitigation Act 2000; Public Law 106-390 new approaches to hazard mitigation planning. **Section 322** emphasizes the need for states, local governments, and tribal entities to coordinate with each other in the mitigation planning process and the implementation of related activities and projects. In addition, it requires states to prepare a Mitigation Plan as a condition for receiving economic assistance for disasters and creates incentives to increase coordination and integration of state mitigation activities with municipalities. Section 322 establishes as a new requirement the creation of local plans and authorizes up to 7% of available HMGP funds to be used in the development of state, local (municipal), and tribal entity mitigation plans.

Coastal Barrier Resources Act (CBRA), Public Law 97-348, approved on October 18, 1982.
It seeks to discourage any development in areas identified as fragile or sensitive to wildlife, as well as prone to social disasters from natural causes, such as flooding, by prohibiting the allocation of federal funds or loans. Federally funded activities such as FEMA-administered flood insurance, U.S. Corps of Engineers projects, and federal assistance for road construction, sanitary sewers, drinking water systems, airports, and bridges are prohibited in these areas, according to the Act.

National Tsunami Hazard Mitigation Program (NTHMP).
In 1995, the U.S. Congress directed the National Oceanic and Atmospheric Administration (NOAA) to form and lead a federal/ state working group to develop a plan for reducing tsunami risk to U.S. coastal communities. This group formed what has become a model for federal/state partnerships—the National Tsunami Hazard Mitigation Program (NTHMP). Following the 2004 Indian Ocean tsunami, Congress passed the Tsunami Warning and Education Act to strengthen the capabilities of this partnership "to improve tsunami preparedness of at-risk areas in the United States and its territories."[45] An update to this act—the Tsunami Warning, Education, and Research Act—was signed into law in 2017. In Puerto Rico, these efforts have been coordinated at the University of Mayagüez, Puerto Rico (UPRM), and by UNESCO's IOCARIBE for the regional areas.

NTHMP includes NOAA, the Federal Emergency Management Agency, the U.S. Geological Survey, and 28 U.S. states and territories (states). This strong and active partnership connects states with the federal agencies

[45] https://nws.weather.gov/nthmp/about_program.html

responsible for the U.S. Tsunami Warning System and brings together the expertise and experiences of all the partners. This enables all levels of government to work together toward the common goals of protecting lives and reducing economic losses from tsunamis at the community level.

This program is designed to reduce the impact of tsunamis through disaster assessment, guidance on warning messages, and mitigation. NTHMP works to create tsunami inundation maps, which are broadcast to the news for use in community drills and knowledge of past tsunamis. Mitigation works to improve the dissemination of activities, reduce hazards, create evacuation plans, and create educational materials for the public.

Homeland Security Operational Analysis Center (HSOAC).

The Department of Homeland Security (DHS) must address complex challenges in preventing terrorism, managing U.S. borders, enforcing, and administering immigration laws, safeguarding cyberspace, and strengthening national preparedness and resilience. To support the Department in these missions, RAND operates the Homeland Security Operational Analysis Center (HSOAC) federally funded research and development center (FFRDC) for DHS.

HSOAC provides the government with independent and objective analyses and advice in core areas important to DHS in support of policy development, decision-making, alternative approaches, and new ideas on issues of significance. HSOAC also works with and supports other federal, state, local, tribal, and public- and private-sector organizations that make up the homeland security enterprise.

As part of the documentation needed to evaluate the capacities of the State and Municipalities to direct the mitigation efforts that should be included in the 2021 PRSNHMP, it is extremely useful to include the evaluations and recommendations that were made as part of the following reports commissioned by FEMA and prepared by the consulting firm RAND:

- The Frontlines of Recovery in Puerto Rico: Assessing Hurricane Damage, Needs, and Opportunities for Recovery in Puerto Rico's Municipalities.
- Community Planning and Capacity Building in Puerto Rico after Hurricane Maria: Pre-Disaster Conditions, Hurricane Damage, and Proposed Courses of Action.
- Building Capacity of Puerto Rico's Municipalities for Reconstruction.

These reports are very relevant in terms of needs or opportunities to improve the management capacity of municipalities and agencies in matters related to mitigation.

4.2.3. Other Stakeholders initiatives Related to Hazard Mitigation.

2019 Report Card for Puerto Rico's Infrastructure; American Society of Civil Engineers-Puerto Rico Section.

The American Society of Civil Engineers (ASCE) is the oldest engineering organization in the United States but is now present in 170 countries. The ASCE is dedicated to the development of design and construction codes for infrastructure. However, nationally the ASCE also stands out for its development of the Infrastructure Report Card, to recommend better policies public.

In 2019 the first 2019 Report Card for Puerto Rico's Infrastructure was published document containing about twenty-five recommendations for eight categories of infrastructure. The recommendations are as follows to address the root causes of the problems that affect us, such as poor resource management and limited resilience of the system. Both deficiencies in our infrastructure led to fatal problems after the Hurricane Maria, turning highly complicated the early recovery of Puerto Rico.

ASCE understands that the priority must be to rebuild a resilient infrastructure to natural disasters and for that there are a lot of recommendations by categories (bridges, roads, etc.) of infrastructure. However, to increase their effectiveness, it important to considerate the following recommendation:

> Establish a Puerto Rico Infrastructure Plan with a wide variety of stakeholders and experts in the field. Infrastructure development is a long-term endeavor with significant impacts on economic growth and competitiveness. Puerto Rico should formulate a general Infrastructure Plan with clear priorities and strategies to achieve them. This plan should be approved by the Legislative Assembly but be developed with limited political interference. In the international area, the Caribbean region has some successful examples of a similar approach. For instance, in 2012 the Dominican Republic adopted their National
>
> Development Strategy 2030, which is a long-term plan for development that was enacted into law to ensure continuity in its implementation. The National Development Plan 2030 for Dominican Republic has clear infrastructure goals and indicators.[46]

[46] American Society of Civil Engineers, Puerto Rico Section, 2019 Report Card for Puerto Rico's Infrastructure, Section 2, page 7.

The above recommendation proposes a multi-sectoral group to determine a plan and strategy to follow that incorporates and harmonizes the needs of entities (agencies, professional groups, non-profit groups, central and local governments).

Based on the experience after Hurricane Maria, the lack of information, communication and coordination among different entities, governments, and agencies complicated Puerto Rico's recovery. The ASCE PR recommends establishing a formal group of professionals that in a period of 45-60 days evaluate in a consistent and uniform way the existing Plan and provide recommendations for the 2021 PRSNHMP.

The ASCE recommends that among the members who should belong to such a commission, in addition to these should be CIAPR, FEMA, CAAPR, NWS, USACE, EPA, Association of Contractors and Industrialists Association. This avoids duplication of recommendations and comments.

4.3. Financial Capacity of the State for Hazard Mitigation.

Puerto Rico has state and federal financial resources to, among other things, administer the government structure, offer services to citizens, and develop plans and projects, including those related to hazard mitigation. In recent years, the economy of Puerto Rico has faced great challenges, which is why, since 2005, a public policy of control and reduction of expenses of the agencies and Instrumentalities of the Government of Puerto Rico has been maintained.

Among the measures established are control over appointments and contract awards, reduction in expenses for cell phone services and other services, reduction in the fleet of motor vehicles, reduction of at least 10% of the payroll expenses of trusted personnel, and freezing career employee positions except when the essential services offered by an agency are at risk. It is essential to consider the economic situation that the Island is going through to analyze the financial capacity of the GPR.

It is important to point out that even in the face of the crisis, where a reduction has been observed in the Agencies' budgets to meet the public policy of reducing expenses established, the funds that are regularly assigned to mitigate the dangers have not been directly impacted.

What follows is a discussion of the Budget of Puerto Rico, in general terms, which include the allocation made to each agency for it to fulfill its functions. Thereafter, the plan discusses the federal resources related to the mitigation of hazards to which Puerto Rico has access.

4.3.1 Consolidated Budget of The Government of Puerto Rico.

The Office of Management and Budget (OGP), created pursuant to Act No. 147 of June 18, 1980, is attached to the Office of the Governor. This Organism oversees advising the Governor and the Legislative Assembly in budgetary, technological, municipal, and administrative management matters; carries out the necessary functions that allow the Governor to submit to the Legislative Assembly the Annual Budget for Capital Improvements and Government Operating Expenses and ensures that the execution and administration of the budget by public bodies is conducted in accordance with the laws and resolutions of budget allocations.

The Approved Budget for the Fiscal Year 2020-2021 seeks to allow the fulfillment of ministerial duties, consistent with the application of public policy. Part of the revised resources of the Joint Resolution of the General Budget include for the digital transformation of "pr.gov" cybernetic portal, the digitization of CESCO, Digital Academy, CIS Integration, Smart Cities, for the Federal Opportunities Center (COF), for the acquisition of license technological (Oracle), among others. Likewise, resources are earmarked for the Puerto Rico Innovation & Technology Service Office (PRITS).

It is important to note the differences in the types of budget income and the use that can be made of each fund. As an example, the Public Improvement Fund is used for the development of improvement works, such as road construction, buildings, or the rehabilitation of parks or recreational places. Likewise, own revenues are resources that Public Corporations generate for their services and are used for operational expenses and the development of improvements that are the responsibility of each Corporation, in addition to the specific uses by Law. The main source of the budget was received from the GPR's General Fund.

General Fund.

The role of the General Fund depends on the priorities that are determined annually by the Executive and the Legislative Assembly. The fund manages and accounts for the general activities of the government and those activities for which the government has not established a particular fund. It does not have an advance allocation. Its largest proceeds come from the Department of the Treasury. The Legislative Assembly makes the allocations to cover the various public investment and service programs for each fiscal year. Its resources come from taxation, essentially on income, inheritances, and donations; excise duties on alcoholic beverages, cigarettes, petroleum products, motor vehicles and their accessories; sales and use taxes, among others.

Public Improvement Funds.

It is made up of resources obtained from the sale of bond issues authorized by the Legislative Assembly through laws. These resources are used to finance the permanent improvement program and cannot be used to defray the operational expenses of the agencies.

State Special Funds.

The funds, where certain resources enter for specific purposes in accordance with current legislation, come from tax revenue, tariffs and licenses, charges for services, contributions from people and donations from private entities, and other collections from some government agencies.

Federal Funds.

Contributions made by the United States government for educational, health, social welfare, employment, permanent improvement, and other programs. These remedies do not require legislative action, as their use is determined by federal law.

Budgetary Funds.

Nourished annually by an amount not less than one percent of the total net income of the previous fiscal year. In addition, it is sustained by all income that does not constitute net income from the General Fund, and that is not destined by law for a specific purpose. It is used to cover approved appropriations for any financial year when the income available for the year is not enough to cover them and to honor the payment of the public debt. It also provides economic resources to meet obligations or disbursements of programs with contributions from the United States Government approved and pending receipt and payments of permanent improvement contracts under construction until the assignments and determinations of State and Federal Courts are made effective.

Emergency Fund Act. (Law No. 91-1966, as amended).

On June 21, 1966, the Law to Create the Emergency Fund was approved, Law No. 91-1966, as amended (3 L.P.R.A. §457ss). This is a deposit fund of the Government of Puerto Rico under the custody of the Secretary of the Treasury (3 L.P.R.A. §457). The Emergency Fund will be capitalized annually through a contribution that will be no less than zero-point five percent (0.5%) of the estimated net income submitted by the Department of the Treasury for the preparation of the Recommended Budget charged to the General Fund. The Emergency Fund will never exceed one hundred and fifty million dollars ($150,000,000) (3 L.P.R.A. §458).

The Emergency Fund will be applied to face unexpected and unforeseen public needs caused by calamities, such as wars, hurricanes, earthquakes, droughts, floods, plagues, and to protect the lives and property of people, and public credit (3 L.P.R.A. §459).

However, the law establishes that this fund may not be used for new government activities, nor to increase or supplement, directly or indirectly, the allocations voted to carry out ordinary government services, without the prior consent of the Legislative Assembly (3 LPRA §459).

Public Debt Redemption Fund.
This fund includes the resources generated by a non-exonerated property contribution, equivalent to 1.03%, and the contributions of the General Fund for the payment of the principal and long-term debt of the central government.

Urgent Interest Fund Corporation (COFINA) (Law No. 91-2006).
The Urgent Interest Fund Corporation (by its Spanish acronym COFINA) was created by virtue of Law 91 of May 13, 2006, as amended, to finance the payment or cancellation of the deficit created by the extra-constitutional debt issued to finance the central government's operation. Through the Sales and Use Tax (Impuesto Sobre Ventas y Uso, known by its Spanish acronym as IVU), the government guaranteed the debt issued by this public corporation.

In 2015, amendments to this law were made, and the IVU was increased from 7% to 11.5%. In 2017, COFINA filed for Title III of the PROMESA Act, which allowed the public corporation to undergo a bankruptcy process like that of Chapter 9 for the municipalities of the United States. In 2018, the Oversight Board endorsed the Adjustment Plan (or restructuring proposal) presented by the GPR. The Puerto Rico Legislature voted in favor of it, and it was subsequently presented to COFINA bondholders. On January 9, 2019, the latter also voted mostly in favor of the Adjustment Plan that reduces debt from $17.64 billion to $12.02 billion. On average, under that agreement, bondholders will receive 75 cents for every dollar. Specifically, the senior bondholders will receive 93 cents for each dollar and the junior bondholders fifty-six (56) cents for each dollar. However, on February 9, 2020, the FOMB announced that it had reached another agreement with certain bondholders of the GPR within a broader framework for the Adjustment Plan.

Under the new agreement, GPR debt service (including principal and interest on senior lien bonds of the Appetizing Interest Fund Corporation (COFINA) is reduced by 56%, from $90.4 billion to $39.7 billion. This latest agreement reduces total debt service by an additional $5 billion when compared to the previous Support Agreement that the Supervisory Board had reached with a smaller group of bondholders during 2019.

Distribution of Budgetary Resources.

The budget defines the origin and distribution of resources to the different government agencies and dependencies. Also, under PROMESA, the Government of Puerto Rico has the responsibility of presenting to the FOMB a Fiscal Plan based on austerity measures and control of expenses on the Recommended Budget for the fiscal year 2018-19 and subsequent years. The Approved Budget for the fiscal year 2020-21 is framed within the Fiscal Plan parameters presented. Regarding the origin of resources, the budget from FY 2020-21, the Consolidated Budget for the GPR, amounts to $28,193,400 million. **(Table 4-2).**

Table 4-2: Consolidated Expense Report, Government of Puerto Rico (Rounded to the nearest thousand).

Source of Funding	Fiscal Year 2017-18 (Spent)	Fiscal Year 2018-19 (Spent)	Fiscal Year 2020-21 (Assigned)	Fiscal Year 2020-21 (Approved)	Absolute Change
General Funds	$9,235,697	$8,792,511	$9,051,118	$10,045,190	$994,072
Federal Funds	$7,245,834	$8,409,717	$8,742,526	$8,602,325	$(108,595)
Special Assignments	$6,290,756	$7,332,099	$8,710,920	$8,602,325	$(108,595)
Public Improvement Funds	0	0	$329	$329	0
Loans and Bond Issues	3	200	200		
TOTAL	$22,772,403	$24,534,327	$26,504,893	$28,193,400	$1,688,507

Source: Office of Management and Budget, September 21, 2020.

The distribution of expenses by agencies primarily reflects the State's public policy priorities. Although most government agencies include projects related to the management of emergencies or the mitigation of hazards in their budgets, the most relevant agencies to the 2021 PRSNHMP have been selected. These agencies are PREMB, DNER, PRPB, and OGPe.

[47]Gobierno de Puerto Rico. Presupuesto consolidado por concepto de gasto y origen de recurso años fiscales 2018 al 2021. San Juan: Oficina de Gerencia y Presupuesto, 21 de septiembre de 2020. http://www.presupuesto.pr.gov/PresupuestoAprobado2020-2021/Tablasestadisticas20212020Consolidado20por20Concepto20de20GastoyOrigenRecursoAF20201820al202021.pdf

4.3.2 Budget of the Puerto Rico Emergency Management Bureau (PREMB).

The consolidated budget for the Fiscal Year 2020-21 of PREMB amounts to $11,481,853 based only on the following items: $6,721,000 from the Joint Resolution of the General Budget, and $4,760,853 from Federal Funds. The consolidated total income reflects a decrease of (3,783,469) compared to the resources allocated for the fiscal year 2019-20.

Table 4-3: Budget, Puerto Rio Emergency Management Bureau (PREMB).

Source of Funding	Fiscal Year 2017-18 (Spent)	Fiscal Year 2018-19 (Spent)	Fiscal Year 2020-21 (Assigned)	Fiscal Year 2020-21 (Approved)	Absolute Change
General Funds	$123,583,633	$6,468,729	$5,255,430	$6,721,000	$1,465,570
Federal Funds	$358,678,087	$4,818,229	$4,719,612	$4,760,853	$41,241
Special Assignments	$193,000	0	$300,000	$303,000	$3,000
TOTAL	$485,055,564	$25,274,054	$15,265,322	$11,481,853	$(3,783,469)

Source: PR Department of Homeland Security Finance Department, 2020.

4.3.3 Budget of the Department of Natural and Environmental Resources (DNER).

The Department of Natural and Environmental Resources consolidated budget for the Fiscal Year 2020-21 amounts to $135,110,000. $81,764,000 responded to the Joint Resolution of the General Budget, $50,705,000 of Federal Funds, and $2,641,000 to Special Revenue Funds. The consolidated total income reflects an increase of $31,899,000 than the resources allocated for the fiscal year 2019-20.

Table 4-4: Budget, Department of Natural and Environmental Resources (DNER)

Source of Funding	Fiscal Year 2017-18 (Spent)	Fiscal Year 2018-19 (Spent)	Fiscal Year 2020-21 (Assigned)	Fiscal Year 2020-21 (Approved)	Absolute Change
General Funds	Not provided	$29,513,000	$56,587,000	$81,764,000	$25,177,000
Federal Funds	Not provided	$11,384,000	$12,994,000	$50,705,000	$37,711,000
Special Assignments	$12,6126,000	$14,763,000	$33,630,000	$2,641,000	$(30,989,000)
TOTAL	$12,6126,000	$55,660,000	$103,211,000	$135,110,000	$31,899,000

Source: Department of Natural and Environmental Resources, Budget Office.

4.3.4 Budget of the Puerto Rico Planning Board (PRPB.)

The consolidated budget of the PRPB for Fiscal Year 2020-2021 amounts to $42,603,000. Resources include $12,022,000 from the Joint General Budget Resolution, $0 from Special Revenue Funds, and

$30,581,000 from Federal Funds. The consolidated total income reflects a decrease of $757,000 than the resources allocated for the fiscal year 2019-20.

Table 4-5: Budget, Puerto Rico Planning Board (PRPB).

Source of Funding	Fiscal Year 2017-18 (Spent)	Fiscal Year 2018-19 (Spent)	Fiscal Year 2020-21 (Assigned)	Fiscal Year 2020-21 (Approved)	Absolute Change
Joint Resolution of the General Budget	$8,667,000	$581,000	$12,352,000	$12,022,000	(330,000)
Special Revenue Funds	535,000	0	13,000	0	(13,000)
Federal Funds	$2,579,000	$1,222,000	$30,995,000	$30,581,000	(414,000)
TOTAL	$11,781,000	$13,803,000	$43,360,000	$42,603,000	(757,000)

Source: Puerto Rico Planning Board, Budget Office.

4.3.5 Budget of the Permit Management Office (OGPe)

The consolidated budget of the OGPe for Fiscal Year 2020-2021 amounts to $0. Resources include $0 from the Joint General Budget Resolution, $0 from Special Revenue Funds, and $0 from Federal Funds. The consolidated total income reflects a decrease of $20,808,000 than the resources allocated for the fiscal year 2019-20.

Table 4-6: Budget, Permits and Management Office

Source of Funding	Fiscal Year 2017-18 (Spent)	Fiscal Year 2018-19 (Spent)	Fiscal Year 2020-21 (Assigned)	Fiscal Year 2020-21 (Approved)	Absolute Change
Joint Resolution of the General Budget	$5,979,000		$8,412,000	0	$(8,412,000)
Special Revenue Funds	$7,359,000	$7,199,000	$6,896,000	0	$(6,896,000)
Federal Funds	$8,100,000	$7,582,000	$5,500,000	0	($5,500,000)
TOTAL	$21,438,000		$20,808,000	0	(20,808,000)

Source: Office of Management and Budget, September 21, 2020.

These four agencies allocate specific funds for disaster mitigation, which demonstrates the State's commitment to addressing the identified hazards. These agencies carried ministerial duties to support hazard mitigation.

It is essential to highlight the need for federal resources that constitute the budget of each of the agencies that pertain to risk mitigation in the archipelago.

Rural Improvement Fund (22 LPRA §118) (2018)
In 2018, Chapter 7 was added to the Public Works Law, (22 LPRA §111-121). This chapter relates to rural improvements. Section 118 of the Law establishes a special fund at the Treasury Department, under the exclusive control and administration of the Rural Improvement Commission, which is only to be used by said Commission, in compliance with this chapter, for rural roads, consolidated rural schools, and agricultural farms, taking into account the needs of the rural school population including the payment of salaries of teachers and staff of the consolidated schools, their annexes and dependencies, and preservation of rural roads.

4.4. Federal Resources for Hazard Mitigation.

The Federal Government has a wide range of programs that provide funding and technical assistance for hazard mitigation activities and projects to which Puerto Rico has access. The opportunity to obtain federal funds for mitigation projects strengthens Puerto Rico's capacity to mitigate identified hazards. The following is a general description of federal funding for mitigation projects. Funds that are not directly related to mitigation projects are also discussed, but their allocations allow for projects that benefit or support the mitigation of hazards and the reduction of vulnerability.

4.4.1. Hazard Mitigation Assistance (HMA) Grant Program.

The HMGP program is funded through the Federal Emergency Management Agency (FEMA) and is administered COR3 on behalf of the state. Federal funds are available to cover up to 75% of approved project costs; however, there is a 25% local match requirement that is the responsibility of the applicant town or municipality.

Typical hazard mitigation projects include mitigation of local roads and bridges, home acquisition (buyout), structural elevations or relocations, replacement of undersized culverts, mitigation outreach and education, etc. Project proposals do not need to be directly connected to damages incurred from the most recent declared disaster. HMGP aims to prevent future loss of life and property from disasters; implement state or local hazard mitigation plans; encourage the implementation of mitigation mea sures during the immediaterecovery from a disaster and provide funds for previously identified mitigation measures to benefit the disaster area. Project grants may be awarded for activities such as acquisition, relocation, elevation, and improvements to facilities and property so they can withstand future disasters.

HMGP eligibility requirements include: (1) Communities must have a FEMA approved and adopted local hazard mitigation plan; (2) Communities must be in good standing with the National Flood Insurance Program (NFIP) if a special flood hazard area (SFHA) has been identified in the community and if the proposed project is located within the SFHA; (3) Communities must have an adopted Local Emergency Management Plan (LEMP) in place; (4) The project must conform to both the state and local hazard mitigation plans; (5) The project must provide a beneficial impact on the disaster area; (6) The project must meet all applicable environmental and historic preservation requirements, laws, and regulations; (7) The project must solve a problem independently or be a functional portion of a solution where there is the assurance that the entire project will be completed; (8)The project must be cost-effective.

HMGP applications must be completed in their entirety, including maps, a list of alternative proposals, engineering plans, hydrology studies (if needed), and a full benefit-cost analysis (BCA) in the FEMA-approved format, if applicable.

In May 2019, the GAR announces the availability of Hazard Mitigation Grant Program (HMGP) funds because of the Federal Disaster Declaration for Hurricane Maria (FEMA-4339-DR-PR). HMGP funding is authorized by Section 404 of the Stafford Act. This post-disaster funding helps the GPR to implement hazard mitigation measures to reduce or eliminate long-term risk to people and property from natural hazards. The amount of HMGP funding available to the GPR is derived from the total federal disaster assistance provided under the disaster declaration. As a result of Hurricane Maria, the GPR will receive approximately $2,999,975,000 in federal hazard mitigation funding[48].

[48] José L. Valenzuela, SHMO. Amendment No. 1 - Hazard Mitigation Grant Program Notice of Funds Availability FEMA-4339-DR-PR (Hurricane Maria). Memo to Municipalities, Government of Puerto Rico Agencies, and Private Non-Profit Organizations. May 30, 2019.

Table 4-7: HMGP Funding Priority.

Sector	Percentages	Initial Allocation
Water / Wastewater	20%	$ 599,995,000.00
Power	15%	$ 449,996,250.00
Communications / IT	12%	$ 359,997,000.00
Health and Social Services	11%	$ 329,997,250.00
Municipalities	10%	$ 299,997,500.00
Transportation	7%	$ 209,998,250.00
Education	7%	$ 209,998,250.00
Public Buildings	7%	$ 209,998,250.00
Housing	5%	$ 149,998,750.00
Capacity Building	3%	$ 89,999,250.00
National and Cultural Resources	1.50%	$ 44,999,625.00
Economics	1.50%	$ 44,999,625.00

Source: Office of Management and Budget, September 21, 2020.

Global Match Strategy

The Hazard Mitigation Grant Program (HMGP) funds require a minimum 25% non-federal cost-share match outlined in Title 2 of the CFR, and consistent with the Title 44 of the CFR, the Stafford Act. In general, the non-federal cost share can come from different potential sources. The recipient and the sub-recipients determine their cost-share source such as cash, donate resources, HUD CDBG Funds, Government Loans, and ICC Funds.

In the year 2018, FEMA acknowledges the CDBG funds as the non-federal cost match for the disaster declaration of Hurricane Irma/Maria. As a result, and to ensure the maximum use of all available mitigation dollars, the GPR, through collaboration with COR3 and PRDOH, implemented a global match program for the HMGP allocation available under the Hurricane Maria disaster declaration. Global match allows the Government to address the required non-federal cost-share by funding HMGP-compliant mitigation projects elsewhere, using monies other

than those available through the FEMA HMGP program. The value of those projects acts as a "credit" and is dedicated as the non-federal cost share for HMGP projects. Effective utilization of the global match approach allows the leveraging of federal funds to help communities in Puerto Rico to implement mitigation activities while eliminating the commitment to the financially burdensome requirement of providing the 25% non-federal cost-share match. This allows for residents of the Government to receive the most significant and most efficient benefit from federal grant funding while rebuilding more resiliently.

Guidance on Property Acquisition and Relocation for Open Space.

For property acquisition and structure demolition or relocation project to create open space must comply with the 44 CFR Section 80. These mitigation measures minimize the vulnerability of risks under some areas in Puerto Rico.

Federal law requires properties acquired with FEMA funds in structure demolition or relocation projects to be maintained as open space in perpetuity and Recipient and the sub-recipient to be responsible for oversight in ensuring and enforcing proper land use for coordinating with FEMA on any future land use or property disposition issues. The Recipient will work with the sub-recipient to ensure that the property is maintained following land-use restrictions. The Recipient and sub-recipient should jointly monitor and inspect acquired properties every three (3) years to ensure that the inspected parcels continue to be used for allowable open space purposes. The HMA Guidance Addendum describes all minimum details for the participation of funds, eligibility, requirements, project implementation, monitoring, reporting, inspection, enforcement, and future land uses.

Projects are often implemented and managed by the Recipient at the sub-grant level, meaning that each individual sub-grant requires a minimum of 25% non-federal funding to meet the cost-share requirement for the grant itself. This often creates a financial burden for sub-recipients and can be a hindrance to successfully using the funds available for mitigation opportunities.

For sub-recipients, the result is 100% funding for their projects, eliminating the need to identify a separate non-federal source of funding for the required cost share. Additionally, this approach results in two sets of projects – those funded 100% by HMGP dollars, and those funded 100% by CDBG-DR funds. Both sets of projects are tracked for compliance with all HMGP requirements.

Flood Mitigation Assistance Grant Program (FMA).
The FMA helps states and communities plan and carry out activities designed to reduce the risk of flood damage to insurable structures under the NFIP.

Pre-Disaster Mitigation Grant Program (PDM).

The non-disaster related Pre-Disaster Mitigation Program (PDM) provides competitive financial assistance to eligible sub-recipients to undertake mitigation measures in their vulnerable areas identified in its mitigation plan. In addition to these measures, it also provides financial assistance for planning activities.

Annually, States and territories receive notification from the FEMA informing them of the process, requirements, timeframe, and amount of budget available for competitive participation. In addition, FEMA establishes what the priorities for participation are, but does not limit itself to presenting any alternate mitigation measures to the subrecipients and not align them with the priorities.

The GPR, as an eligible recipient, promotes the PDM assistance alternative because it is not every year that we get a disaster declaration grant. This assistance minimizes the use of government funds to implement necessary mitigation measures and make a country more vulnerable to existing risks. It also promotes the subsidization of mitigation plan updates to comply with participation in the PDM program. In each fiscal year, an analysis is made of the plans that are due and those that are yet to expire. After establishing how many plans need financial assistance, the maximum amount that FEMA establishes for the use of planning measures in that fiscal year is reviewed. At the same time, projections and budget estimates are made based on previous grants; each municipality is informed that its plan is due for participation and requests for funds. Upon receipt of confirmation of participation, a determination is made as to how much budget is available to maximize the annual budget allocated for planning.

These planning proposals and others are submitted to FEMA on or before the deadline for evaluation and determination.

The PDM aims to implement hazard mitigation programs on an ongoing basis to reduce the risk to people and structures in future hazard events and thus reduce dependence on federal funds in future hazard events. Examples of projects that can be carried out with PDM funds are acquisition, demolition, and relocation of vulnerable structures; installation of electrical generators and storm surges; development and updating of Mitigation Plans; educational campaigns and projects; infrastructure rehabilitation; and fire and flood control projects, among others.

4.4.2 Emergency Management Performance Grant Program (EMPG).

The EMPG aims to assist in preparing and managing all hazards and obtaining the necessary resources to support the National Preparedness Goals. In addition to stimulating the development of programs to prevent risks and hazards, including terrorism, and improving planning and resilience through the strengthening and revitalization of housing and infrastructure.

4.4.3 National Dam Safety Program (NDSP).

The NDSP aims to improve public safety and mitigate disasters related to dam failures through regulatory programs, research to enhance expertise on dam construction and rehabilitation, and training of dam safety inspectors.

There are more than 90,000 dams in the U.S., according to the National Inventory of Dams maintained by the US Army Corps of Engineers. Dams operated by Federal agencies are generally well maintained.[49] Nonfederal dams, owned by private companies or public agencies, are typically regulated by state dam safety programs. The Federal Energy Regulatory Commission also regulates non-federal dams that generate hydropower. A November 2019 study by the Associated Press reported that there were at least 1,680 dams in 44 states considered to be "high hazard" and in inadequate or unsatisfactory conditions. A dam is categorized as a "high hazard" if a failure would result in the loss of human life. It is also reported that most dams in the U.S. are over 50 years old, much older than their design life. All dams in Puerto Rico are listed under this classification.

The Association of State Dam Safety Officials (ASDSO) estimates that the cost of repairing high hazard nonfederal dams is estimated at $20.4 billion (2019 ASDSO study). The cost of repairs increases to $66 billion if one includes significant and low hazard nonfederal dams. For the Federal fiscal year 2020, the FEMA High Hazard Dam Safety Program had $10 million in available grant funding.

4.4.4 Emergency Watershed Protection Program (EWP).

The EWP is intended to provide technical and financial assistance to carry out emergency measures to reduce runoff, prevent soil erosion, and protect life and property from floods, droughts, erosion, landslides, and sedimentation the watershed when any natural hazard causes sudden watershed deterioration.

4.4.5. Regional Coastal Resilience Grants Program.

This program aims to develop and implement activities to strengthen coastal regions, communities, and economic sectors to the negative impacts of extreme weather events, climate hazards, and changing ocean

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[49] Pineda, Ricardo (2020). Recommendations for Addressing Dam Safety. News & Views. Association of State Floodplain Managers. 33 (3), 3.

conditions. The program assists in protecting and conserving sensitive coastal areas and provides the benefit of reducing development in high coastal hazard areas.

4.4.6. National Coastal Wetlands Conservation Grant Program (NCWCG).

The NCWCG program aims at the long-term conservation of coastal wetlands through the conservation, restoration, acquisition, and management of wetlands because of their importance in the ecosystem, as they assist in flood mitigation, control soil erosion, stabilize land through the maintenance of drainage and sedimentation control in coastal areas, act as a buffer zone against water pollutants, and support important biological diversity.

4.4.7. Community Development Block Grant- Disaster Recovery (CDBG-DR).

Two (2) months after the hurricanes, in November 2017, Governor Ricardo Rosselló commissioned an initial damage assessment, the Build Back Better report,[50] that identified an estimated $94 billion in recovery need from fourteen (14) possible funding sources. The Amended Action Plan outlined in the following pages includes further analysis of early damage estimates and informs an initial program design to address these needs with the first $1.5 billion authorized by Public Law 115-56 and Public Law 115-72, and announced through Federal Register 83 FR 5844, and the second tranche of $8.2 billion announced through Federal Register 83 FR 40314. The U.S. Department of Housing and Urban Development (HUD) is the federal oversight agency for these funds administered through the Community Development Block Grant – Disaster Recovery (CDBG-DR) framework overseen by HUD.

The Government of Puerto Rico has designated the Puerto Rico Department of Housing (PRDOH) as the agency responsible for administering CDBG-DR funds in close collaboration with the COR3. Under the commitment to assist the Funds efficiently and transparently, PRDOH built its "Action Plan" to govern the Island's recovery and reconstruction after receiving multi-sector recommendations.

CDBG-DR funds are allocated to states or jurisdictions affected by disasters. It requires congressional authorization and an allocation notice. This money must be used for needs that are discovered or not addressed by other assistance programs. The use of these funds should ensure communities' long-term recovery, specifically in areas of housing, infrastructure restoration, and economic revitalization.

[50]The Build Back Better Puerto Rico, Request for Federal Assistance for Disaster Recovery, November 2017 is a damage assessment completed November 13, 2017 under the direction of Governor Ricardo Rosselló and funded by three major foundations dedicated to a sustainable and equitable recovery effort in Puerto Rico: Ford Foundation, Open Society, and Rockefeller. The Build Back Better report is a first estimate of recovery need across all sectors and a request for federal resources from 14 identified entities.

4.4.8. Community Development Block Grant – MIT (CDBG-MIT).

On February 9, 2018, the U.S. President signed into law the Bipartisan Budget Act (Public Law 115-123), which provided $28 billion in Community Development Block Grant - Disaster Recovery (CDBG-DR) funding and directed the U.S. Department of Housing and Urban Development (HUD) to provide the U.S. Department of Housing and Urban Development (HUD) with the necessary funding for the U.S. Department of Housing and Urban Development (HUD). (HUD) to allocate no less than $12 billion for mitigation activities in proportion to amounts awarded to qualified disaster funding recipients in 2015, 2016, and 2017. This amount was increased to $15.9 billion after HUD completed an unmet needs assessment and awarded funds to eighteen (18) recipients through the newly created CDBG-MIT.

A Federal Register Notice published by the Department on August 30, 2019 (84 FR 45838), allocated $6.875 billion of CDBG–MIT funds to 14 state and local governments and described the grant requirements and procedures, including waivers and alternative requirements applicable to CDBG–MIT funds ("the CDBG–MIT Notice"). The CDBG–MIT Notice recognizes that CDBG–MIT funds are to be used for distinctly different purposes than CDBG–DR funds and that the level of funding and nature of programs and projects that are likely to be funded requires all CDBG–MIT grantees and their sub-recipients to strengthen their program management capacity, financial management, and internal controls.

Under the CDBG–MIT Notice, each grantee is required to strengthen its internal audit function, specify the criteria for sub-recipient selection, increase sub-recipient monitoring, and establish a process for promptly identifying and addressing conflicts under the grantee's conflict of interest policy. The CDBG–MIT Notice also states the Department's intent to establish special grant conditions for individual CDBG–MIT grants based upon the risks posed by the grantee, including risks related to the grantee's capacity to carry out the specific programs and projects proposed in its Action Plan. The CDBG-MIT Action Plan recognizes the various sources of funding available for hazard mitigation. The CDBG-MIT grant, in combination with FEMA Hazard Mitigation Assistance, mitigation projects funded by the U.S. Army Corps of Engineers, and projects from other federal entities, offers Puerto Rico the potential to mitigate loss of life and damage to critical infrastructure in the future.

PRDOH's commitment to mitigation goes beyond the responsible investment of the $8.3 billion grant assigned to Puerto Rico for a 12-year timeline. The CDBG-MIT programs are designed to fund transformative projects and plans, that will significantly increase resilience of Puerto Rico, at the Island-wide, municipal, community and household level. Programs such as RAD Collection and Planning and Capacity Building are meant to provide a foundation (beyond the 12-year grant lifecycle) for the Puerto Rico of the future: data-driven decision-making, with strengthened regional collaboration, and capitalizing on existing funding for the investment in forthcoming mitigation efforts such as update of the local hazard mitigation plans, leveraging other federal investments and available finding, and the improvement of the risk and hazards data and the general knowledge of those risks throughout Puerto Rico.

4.4.9. Emergency Farm Loans (EFL).

The Agricultural Services Agency of the USDA offers loans to assist post-disaster. They can be used to restore or replace essential property, pay all or part of the production costs for the year of the disaster, pay essential family living expenses, reorganize the agricultural operation, or refinance certain debts.

The Emergency loan program is triggered when a natural disaster is designated by the Secretary of Agriculture, or a natural disaster or emergency is declared by the President under the Stafford Act. These loans help producers who suffer qualifying farm related losses directly caused by the disaster in a county declared or designated as a primary disaster or quarantine area. Also, farmers located in counties that are contiguous to the declared, designated, or quarantined area may qualify for emergency loans.

Farm Service Agency (FSA) administers four types of disaster designations: U.S. Department of Agriculture (USDA) Secretarial disaster designation; major Presidential disaster and Presidential emergency declaration; FSA Administrator's Physical Loss Notification (APLN); and Quarantine designation by the Secretary under the Plant Protection Act or animal quarantine laws.

An FSA APLN is for physical losses only, such as a building destroyed by a tornado. Livestock-related losses are considered physical losses. An APLN is requested by FSA's Administrator by an FSA SED. A quarantine designation is requested by the Secretary of Agriculture by an FSA SED. A quarantine designation authorizes EM loans for production and physical losses resulting from quarantine. For production losses, a 30% reduction in a primary crop in a designated or contiguous county is required. Losses to quality, such as receiving a 30% reduced price for flood-damaged crops, may be eligible for assistance, too.

Emergency loan funds may be used to restore or replace essential property, pay all or part of production costs associated with the disaster year, pay essential family living expenses, reorganize the family farming operation, refinance certain non-real estate operating debts.

qualify, the person seeking the EFL must: be the owner or operator of land in an area declared a disaster by the President of the United States, or designated by the Secretary or the Secretary of Agriculture as a disaster or quarantined area; be the operator or a family farm operator and have enough experience in agriculture or livestock; be a citizen or citizen or with permanent residence in the United States; have suffered at least a thirty percent (30%) loss in crop production or a physical loss to your livestock, livestock products, real estate, or personal property; have a good credit history (credit cannot be obtained from commercial sources); be able to provide collateral to secure the loan, and can repay the emergency loan.

4.4.10. FEMA Public Assistance for COVID-19.

In accordance with section 502 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. 5121-5207 (the "Stafford Act"), eligible emergency protective measures implemented under the direction or guidance of public health officials to respond to the COVID-19 emergency may be reimbursed under FEMA's Category B program. FEMA will not duplicate assistance provided by the U.S. Department of Health and Human Services. (HHS), including the Centers for Disease Control and Prevention (CDC), or other Federal agencies.

State, territorial, tribal, and local government entities, and specific private nonprofit organizations can apply for Public Assistance. FEMA assistance will be provided on a 75 percent federal cost-share basis. This assistance will require an agreement between FEMA and the State/Territory/Tribal, as appropriate, and execute a corresponding emergency plan. Local governments and other applicants eligible for Public Assistance will submit their applications through their respective state, tribal, or territorial jurisdictions.

COVID-19 Pandemic Operational Guidance for the 2020 Hurricane Season.
In May 2020, FEMA-Headquarters release a Guide to help emergency managers and public healthTo officials prepare for disasters while continuing to respond to and recover from coronavirus (COVID-19). This will help all partners, private sector and NGOs gain an understanding of the government's posture, planning and readiness efforts.

4.5. Progress to the State's Mitigation Capability.

As can be seen, Puerto Rico has a variety of laws and regulations, both state and federal, that regulate the State's planning processes, including all those related to hazard mitigation. In addition, it has financial resources, both state and federal, that are allocated annually and others that the State, through its agencies, could obtain through federal proposals. On the other hand, it has analysis tools to study the impact of hazards, the change of hazards, and the vulnerability of the population and structures. The laws and resources allocated to hazard management and mitigation reflect Puerto Rico's strength and capacity for mitigation to protect its inhabitants from disasters and to prevent them. However, it is essential to identify the challenges or obstacles that the State has had to ensure effective hazard mitigation from the events of Hurricane Maria to the present.

4.5.1. Obstacles to the State's Mitigation Capabilities.

This update identified challenges and obstacles that can be improved to strengthen the State's mitigation processes and capacity even with the availability of legal, regulatory, financial, and analytical resources. As necessary factors for the hazard mitigation process, the aspects discussed below emerged from the process of analyzing and updating the 2021 PRSNHMP and the review of literature on hazards and recommendations proposed in specialized technical studies. Addressing the challenges or obstacles that were identified are essential for strengthening the State's mitigation capacity.

Government of Puerto Rico Fiscal Scenario.

The economic situation in Puerto Rico has been declining in recent years, significantly affecting society's different sectors. By 2017 Puerto Rico's debt was estimated at approximately $74 billion in addition to $50 billion in pension obligations, making it one of the largest potential bankruptcies on record[51].

Indeed, the economy is at its most critical point and facing a bankruptcy process. In 2016, it was assigned by the United States Congress (Garcia, 2018) the FOMB through the PROMESA law to provide a legal framework to reduce the island's debt[52]. This law ratified article IV, section 3, of the United States Constitution, which states that Congress has the power to make all laws and regulations necessary to administer its territories, meaning that the Board has complete control over the territorial and state laws of Puerto Rico.

Economic and social problems increased in the hurricane season in 2017. Hurricane Irma broke out on September 6, and Hurricane Maria struck on September 20, causing substantial and more significant damage than Hurricane Irma. Hurricane Maria killed 4,645 people[53]. It was one step away from being category five and turned out to be the strongest in nearly ninety years of history. Hurricane Maria served as a detonator to the high level of vulnerability that our Island has and turned out to be a social phenomenon due to the difficult economic situation and fiscal severe situation that has not allowed

[49] Jackie Wattles· Claves para entender la grave crisis económica de Puerto Rico”· De mayo de 2017· CNN en Español·
[50]Williams (2019). New York Times.
[53] José G. García López (2018). Apuntes sobre la evaluación de los daños causados por el huracán María., 162-163

the Government to access the U.S. capital markets in recent years to finance the program of permanent improvements and to maintain the weak infrastructure of electrical energy, aqueducts, and roads.

Due to the economic situation the country has faced in recent years, it has not been possible to strengthen the road infrastructure and the infrastructure of the agencies that provide essential resources to Puerto Ricans such as electricity and water. The Economic Report to the Governor (2017), in compliance with the PRPB provisions, compares the economic situation of Puerto Rico before Hurricane Maria with the states affected by Hurricane Katrina along the Gulf Coast. However, the city of New Orleans received the most significant impact[54]. This economic and fiscal situation in Puerto Rico has been a substantial obstacle to achieving an efficient mitigation capacity. It has not been possible to access the capital markets for permanent improvements and provide maintenance to the weak infrastructure of electricity, aqueducts, and roads.

Although the analysis carried out does not show that the country's fiscal crisis has reduced its allocations to specific funds for hazard mitigation, it is essential to ensure that this does not happen, because of the possibility that the fiscal crisis will worsen. The public policy of expenditure reduction in Puerto Rico provides for measures that, although they do not directly reduce the allocated budget, impact the hiring of personnel, which could include personnel-related to ensuring the implementation of planning or hazard mitigation laws or regulations. Puerto Rico needs to consider that neglecting the mitigation of hazards could have consequences that affect the social, economic, and environmental sectors, which could cause a general detriment of mitigation actions and an increase in the vulnerability of hazards.

Management of other New Risks.

Earthquakes.

More than 500 earthquakes greater than M2.0 have shaken Puerto Rico since December 28, 2019. So far, the most significant events, including one of M5.8, followed by one of M6.4, occurred within a 24-hour time window. Around thirty-three earthquakes of magnitude 4.5, two of magnitude 5.6, and one of magnitude 6.4 developed, which led to the declaration of a state of emergency[55].

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[54] Junta de Planificación de Puerto Rico (2017). Informe Económico al Gobernador, 53-54.

[55] Chaffin Mitchell (2020). Damage reported in Puerto Rico following 5.4 magnitude earthquake. AccuWeather. Retrieved of https://www.accuweather.com/en/weather-news/damage-reported-in-puerto-rico-following-5-4-magnitude-earthquake/732894

The FOMB allowed the GPR to use the Emergency Fund (up to $46.8 million available in the Fiscal Year 2020 Emergency Reserve) for work related to earthquakes recorded on the island since 28 December 2019 extended until 30 May 2020 by repeated earthquakes events.

The earthquakes damaged structures in the southwestern part of the island, including houses, schools, municipal buildings, roads, and bridges. There were power outages and approximately 300,000 homes without potable water service. The M5.8 event caused the collapse of Punta Ventana, a natural rock arch and popular tourist spot in the Municipality of Guayanilla. There were people with multiple physical injuries and one (1) death in the Municipality of Ponce.

Seismic risk maps indicate that Puerto Rico has seismicity comparable to the western United States. More importantly, the island has two different seismicity regions. The west-southwest area is the most dangerous for strong seismicity and shallow hypocenters, which increases the danger of earthquakes in that area. This danger, combined with a large population and infrastructure that has not experienced a strong earthquake in recent times, results in great vulnerability to the danger of earthquakes in Puerto Rico and compromises the public safety within the Island.

Coastal problems worsened by recent natural phenomena.
The new PRPB flood maps reflect that some 252,813 structures are in flood-prone areas. Of these, some 3,628 are in an area called "A Costera," at the mercy of heavy swells. This scenario requires that additional measures be needed in the case of floodable regions, such as filling in tanks, raising infrastructure above those flood levels, or incorporating measures, such as waterproofing, so that the water does not gain access. Although these new measures represent an economic impact for developers (as they are not designed as part of basic construction), they are necessary to protect life and property.

The management of the coastal zone in Puerto Rico faces many challenges and obstacles[56]. Some of the challenges presented are:

- Lack of Public Policy. There is still no law in Puerto Rico on integrated coastal planning to mitigate the various damages and risks that have developed over the years on the beaches. This law must recognize the beaches as a vital infrastructure of the country.

[56]Barreto, M. (2020). Change in the Coasts and Climate Change. Presentation sponsored by Ecoexploratorio: Museum of Sciences in Puerto Rico.

- Coastal Infrastructure. Much of Puerto Rico's vital infrastructure is found in coastal areas such as, for example, some major roads, sanitation infrastructure, drinking water infrastructure, power generation complexes, airports, hospitals, ports, hotels, used treatment plants, and nautical clubs.
- Lack of planning and poor coastal management decisions. The coordination developed by the state to ensure the protection and mitigation of risks on the coasts has not been efficient and has not fully benefited these areas. After Hurricane Maria, the vulnerability of the coasts to future disasters has increased. The coasts of Puerto Rico have changed since the earthquakes and hurricanes, and therefore, changes in all plans related to the coasts of Puerto Rico must be addressed.

On the other hand, almost three years after Hurricane Maria and with active seasons of cyclonic activity, urban flooding scenarios can be repeated that, except for short-term prevention and clean-up measures, no circumstances have changed aimed at mitigating the severe problems experienced during this event. The Puerto Rico Planning Society (SPP) states that in the short term and with a small budget, the options are limited to

cleaning sewers, extracting sediments from water bodies, ensuring that river mouths are clear, identifying obstructions that prevent water flow if it goes out of its channel, and planting plants that absorb water and cover the immensity of impermeable cement. Solutions to root problems must be long-term[57].

Tsunamis.

A tsunami in Puerto Rico is a real danger. Private educational organizations such as the EcoExploratorio claim that there are 504 geological faults between Puerto Rico and the US Virgin Islands that can cause a tsunami[58]. A tsunami can threaten us at any time either because it originated from a strong earthquake (magnitude greater than 7.0) occurring near or below Puerto Rico on one of these faults or from an underwater landslide occurring without an earthquake.

One of the most significant risks facing our island is a tsunami due to underwater landslides. In recent years, studies and maps have been made of Puerto Rico's coastal environment and the Atlantic Ocean floor just north of the island. These studies have confirmed that, due to steep slopes or rugged topography, landslides have occurred in the past, and a devastating tsunami could form for people living,

[57]Saker, G. "El miedo a inundaciones en la isla sigue latente". El Nuevo Día. 4 de julio de 2018. Retrieved from https://jp.pr.gov/Portals/0/Prensa/Noticias/201807050913.pdf?ver=2018-07-05-144800-883

[58] https://ecoexploratorio.org/amenazas-naturales/tsunami/tsunami-en-puerto-rico/

studying, or working on the coasts. In this type of tsunami, the warning capacity will be less rapid and effective than when an earthquake occurs.

The characteristics of the population in coastal areas indicate a greater vulnerability for the following municipalities: Mayagüez, San Juan, Arecibo, Aguada, Carolina, Ponce, Loíza, Aguadilla, Cabo Rojo, Hatillo, Añasco, Dorado, Luquillo, Barceloneta, Juana Díaz, Camuy, Fajardo, Rincón, Toa Baja and Salinas. A tsunami's effects will be felt in the coastal area, precisely where a significant population of people is concentrated and where a large part of the port and electricity generation operations take place.

Pandemics.

The response of the public health system in Puerto Rico to the coronavirus has been inefficient, and that the Island's public health system needs to be strengthened. Some of the deficiencies are:

- Lack of effective response that prioritizes public health rather than the economy.
- Lack of educational campaigns.
- Lack of planning to provide hygiene resources to the population.
- Lack of planning for health workers to get sick and bring in more professionals due to staff shortages.
- Lack of medical training.

Implementation of Available Regulations.

Sometimes, the complexity and bureaucratic processes in the State agencies delay the review and evaluation of the impacts of the projects proposed by the developers. These delays directly impact project costs, which sometimes leads some developers to take the risk of developing projects without completing the formal endorsement process by the State agencies. This results in projects that do not comply with the regulations and, consequently, the general deterioration of environmental conditions in the surrounding areas.

To standardize processes and classifications of land use, to provide further efficiency to granting permits, in December 2020, the PRPB approved a new regulation of permits, Reglamento Conjunto de Permisos, that will uniformly address the uses of land or structures to be given in our island. The PRPB reduced the number of qualification districts from 50 to 22 by consolidating those whose uses are similar so that the consultation and permitting processes are more agile.

However, when land use practices and development patterns diminish natural systems' capacity, the sustainability of the natural system is reduced. In Puerto Rico, excessive growth has caused a reduction in the natural resilience provided by wetlands, streams, rivers, beaches, dunes, and mangroves. It has also left more communities exposed to the effects of natural disasters. The expansion of unplanned development has dramatically increased the amount of flat and impervious surfaces, such as roads and parking spaces, which can increase the problem of flooding. Moreover, development pressures in rural areas have precipitated this development in areas susceptible to hazards, such as mountain slopes and hills. This type of action contributes to deforestation and reduced absorption capacity of soils during heavy rains, increasing the frequency of flash floods and landslides.

In these situations, it is essential to correctly implement the laws or regulations related to project planning and evaluation, but in a way that does not penalize the developer in cost and time, which could lead to informal construction.

Coastal Zone Management.
In coastal areas, development pressure and the limited availability of land have made the Coastal Zone Management Plan and the Special Flood Hazard Areas Regulations (Regulation No. 13) important regulatory documents for Puerto Rico and directly related to hazard mitigation. Unfortunately, the implementation of

these protection policies has not been constant. Coastal developments have destroyed mangroves and coastal environments. The loss of these areas, which act as natural buffers, has made coastal areas more vulnerable to damage from waves and coastal erosion.

Both PRPB and FEMA amended the Special Flood Hazard Areas Maps, based on the information collected after Cyclone Maria. The structures established in the areas identified in the maps will have to be governed by Regulation No. 13.

Management of the coastal zone is essential for hazard mitigation in Puerto Rico. As noted above, 44 of the 78 municipalities in Puerto Rico are coastal, representing 56% of the municipalities. On the other hand, there are ports, airports (including the Luis Muñoz Marín International Airport), highways, structures of all types, critical infrastructure, and a large population located in the coastal zone. Climate change, together with the characteristics or trends observed for years on the coasts of Puerto Rico, points to the urgency of correctly implementing regulations related to coastal areas and flooding.

Flow of information and relationship between public policies for development, planning, and hazard mitigation.

Although a contradiction between development, planning, and hazard mitigation policies is not directly identified, it is essential to maintain a balance between public policies that promote economic development and policies that seek to manage the territory and reduce vulnerability to natural hazards. Established procedures and regulations suggest an interrelationship between agencies related to territorial planning and hazard mitigation processes; however, it would be advisable that the next update of the Plan evaluates and identifies the results of this interrelationship.

The articulation of agencies and information flow is important so that efforts are not duplicated, and hazard mitigation processes and actions are initiated in the early stages of plan and project analysis. To this end, it is essential to increase efforts to coordinate interagency reviews, clarify primary and support functions, and ensure that laws are implemented to balance development, planning, and hazard mitigation processes. This relationship should be based on a sound understanding of the environment, natural hazards, and their potential impacts.

It is still not commensurate with the severity of the situation that more knowledge on the predictable impacts of climate change consequences and mitigation projects should consider the longer-term implications of climate change. We see the immediate need, but the projection is that extraordinary events will be more intense and frequent, and we would be relying on a team that would be dealing with a situation that, in the long term, will be obsolete and maintenance costs would be higher.

4.5.2. Challenges in the State's Mitigation Capability.

One of the limitations recognized by this Plan was the administrative difficulty PREMB faced in hiring specialized technical human resources assigned to work directly with the various representatives of the GPR agencies. This situation was because, as of 2017, the agency has been focused on coordinating the response work for the multiple disasters that have struck the Island since that year.

Another limitation identified in the Plan was due to the difficulty that State agencies in validating and submitting information on their mitigation projects and updating their critical infrastructure. This was due to the redefinition of priorities within the agencies due to the earthquakes of early 2020, the lockdowns decreed by the COVID-19 emergency and their corresponding response work. The period before and after the General Elections (electoral ban) and their respective transition processes during the last quarter of 2020 also increased limitations in that sense. Given these scenarios, the 2021 PRSNHMP Steering Committee identified alternative strategies to obtain the necessary information to facilitate the development of mitigation strategies. Chapter 6 details the methodology used and the sources of information that were identified.

Difficulties on the use of data and information for risk and hazard analysis.

In searching, using, and analyzing data and information to characterize the risks, multiple associated difficulties arose, such as lack of metadata of the dataset, accessibility to data and information, incomplete data, and information. These difficulties can produce errors that, if not identified, can lead to significant mistakes that can lead to the description of an inaccurate risk profile. The following limitations are highlighted below:

Updating Data.

Many of the data and data information are not up to date. It is necessary to generate new sources of revised information that are periodically updated according to risks or events. The updating of data is the basis for developing timely and correct risk characterization. It is recommended that there be a program that provides funding and support to review the base data used for risk characterization.

Among the risks that need data, updates are faults and fissures and floods (coastal and riverine/tsunami). The January 2020 earthquake events caused subsidence in southwestern Puerto Rico, which presents a new variable that defines a different geophysical scenario. This could make several of the current models used to determine the extent of flooding unrealistic.

Absence of Metadata.

Several of the data sets do not have detailed metadata to validate their legitimacy and recognize their nature. The lack of data validation can lead to uncertainty and distrust in the analysis processes and make it impossible to generalize the results to be used to develop proper mitigation plans. Only data sets that could be validated were used for this report. It is recommended that detailed metadata using the required spatial standards be requested for all consultative work that generates data.

Lack of Original Data Repository.

It was identified that for several risks, only processed information from the data analysis was available. The original datasets were not available. The lack of availability of these does not allow the studies' replicability or the generation of other risk analysis approaches. It is recommended that future new data acquisition processes require that the original datasets be provided in conjunction with the information requested from the agency or advisory group.

Fragmented Information:

The data and information obtained to perform the analyses sometimes present fragmentation and disconnection between the variables used. In several cases, disparities of variables, methods used, the scale used, and ways of obtaining data that are not necessarily the correct ones to carry out specific analyses have been identified.

Data Accessibility.
There are multiple complications to obtain accessible data on the variables to be studied, substantially hindering project creation and determination of work plans.

Data Centralization.
It is necessary to create data banks that specialize in each natural and/or anthropogenic risk to speed up the analysis processes and ensure their quality. This facilitates project development processes and provides data legitimacy and process replication. These data should be managed in a spatial information center where the various offices can acquire them to generate new analyses.