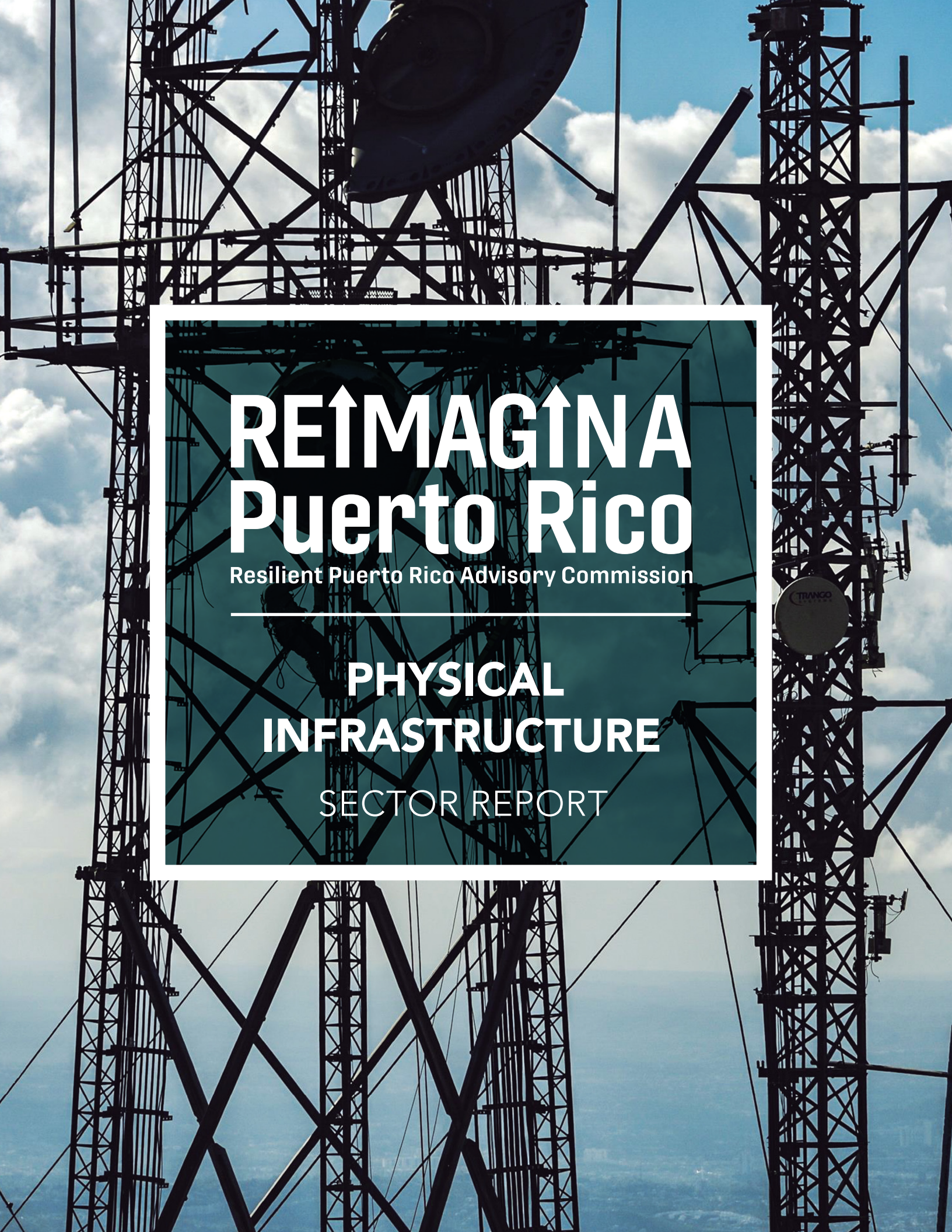


REIMAGINA Puerto Rico

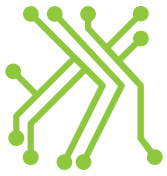
Resilient Puerto Rico Advisory Commission

PHYSICAL INFRASTRUCTURE

SECTOR REPORT

REIMAGINA Puerto Rico

Resilient Puerto Rico Advisory Commission



PHYSICAL INFRASTRUCTURE

SECTOR REPORT

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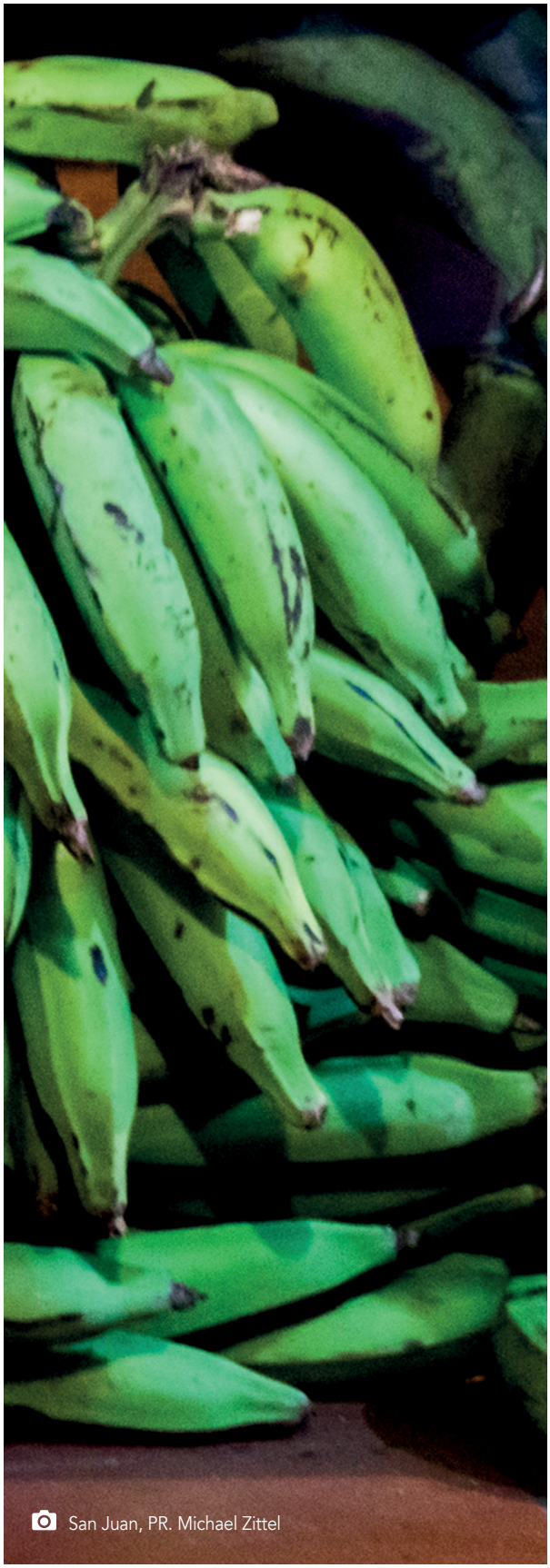


San Juan, PR. Michael Zittel

Acronyms

100 RC 100 Resilient Cities

ACA Affordable Care Act

ACS American Community Survey

ADUs Accessory Dwelling Units

AES Agricultural Extension Service

AGC Associated General Contractors of America

AIDIS Inter-American Association of Sanitary and Environmental Engineering

AMA, by its Spanish acronym Puerto Rico Metropolitan Bus Authority

ARRA American Recovery and Reinvestment Act

ASSMCA, by its Spanish acronym Puerto Rico Administration of Mental Health and Anti-Addiction Services

BLS United States Bureau of Labor Statistics

BTOP Broadband Technology Opportunities Program

Business PREP Business Preparedness and Resiliency Program

CAAPPR, by its Spanish acronym Puerto Rico College of Architects and Landscape Architects

CAGR Compound Annual Growth Rate

CAIDI Customer Average Interruption Duration Index

CBA Community Benefits Agreements

CBO Community-Based Organizations

CCLC United States Department of Education - 21st Century Community Learning Centers

CDBG Community Development Block Grant

CDBG-DR Community Development Block Grant Disaster Recovery

CDBs Community Development Banks

CDC Center for Disease Control and Prevention

CDCorps Community Development Corporations

CDFIs Community Development Financial Institutions

CED Community Economic Development

CHDOs Community Housing Development Organizations

CHIP Children's Health Insurance Program

CHP Combined Heat Power

CIAPR , by its Spanish acronym Puerto Rico College of Engineers and Land Surveyors

CNE Center for a New Economy

COFECC, by its Spanish acronym Corporation for Business Financing of Commerce and Communities (now known as "lendreamers")

COOP Continuity of Operations Plan

COR3 Puerto Rico Central Office of Recovery, Reconstruction, and Resilience

CRA Community Reinvestment Act

CRF City Resilience Framework

CRIM, by its Spanish acronym Puerto Rico Municipal Revenue Collection Center

CSR Corporate Social Responsibility

DACO, by its Spanish acronym Puerto Rico Office of Consumer Affairs

DEDC Puerto Rico Department of Economic Development and Commerce

DHS United States Department of Homeland Security

DIRS Disaster Information Reporting System

DIY Do It Yourself

DNER Puerto Rico Department of Natural and Environmental Resources

DOLHR Puerto Rico Department of Labor and Human Resources

DOS United States Department of State

DTPW Puerto Rico Department of Transportation and Public Works

EDA United States Economic Development Administration

EOP Puerto Rico Emergency Operation Plan

EPA United States Environmental Protection Agency

EQB Puerto Rico Environmental Quality Board

EQIP Environmental Quality Incentives Program

EWP-FPE Emergency Watershed Protection - Floodplain Easement Program

FAA Federal Aviation Administration

FCC Federal Communications Commission

FEMA Federal Emergency Management Agency

FHWA Federal Highway Administration

FIDEVI, by its Spanish acronym Puerto Rico Housing and Human Development Fund

FIRM Flood Insurance Rate Maps

FOMB Financial Oversight and Management Board for Puerto Rico

FQHCs Federally Qualified Health Centers

FTA Federal Transit Administration

GAR Governor's Authorized Representative

GIS Geographic Information System

HHS United States Department of Health and Human Services

HiAP Health in All Policies

HIPAA Health Insurance Portability and Accountability Act

HMGP FEMA Hazard Mitigation Grant Program

HMP Puerto Rico Hazard Mitigation Plan

HRSA United States Health Resources and Services Administration

HUD United States Department of Housing and Urban Development

INE Instituto Nueva Escuela

IoT Internet of Things

IRP Integrated Resource Plan

IRS Internal Revenue Service

ISWM Integrated Solid Waste Management

KPIs Key Performance Indicators

KW Kilowatt

LIHTC Low-Income Housing Tax Credits

LISC Local Initiatives Support Corporation

LMI Low to Moderate Income

LQ Location Quotient

MA Medicare Advantage

MBA Mortgage Bankers Association of Puerto Rico

MCOs Managed Care Organizations

MGD Million Gallons Per Day

MIT Massachusetts Institute of Technology

MSA Metropolitan Statistical Area

MUSV Movimiento Una Sola Voz

NAICS North American Industry Classification System

NDRF National Disaster Recovery Framework

NERC North American Electric Reliability Corporation

NFIP National Flood Insurance Program

NGOs Non-governmental Organizations

NIH National Institutes of Health

NOAA National Oceanic and Atmospheric Administration

NRCS Natural Resources Conservation Service

NTIA National Telecommunications and Information Administration

O&M Operations and Maintenance

OCIO Office of the Chief Information Officer of Puerto Rico

OCPR Office of the Comptroller of Puerto Rico

OCS, by its Spanish acronym Office of the Commissioner of Insurance of Puerto Rico

ODSEC, by its Spanish acronym Office for the Community and Socioeconomic Development of Puerto Rico

OMB Puerto Rico Office of Management and Budget

OPPEA, by its Spanish acronym Puerto Rico Governor's Office for Elderly Affairs

OSTDS Onsite Sewage Treatment and Disposal Systems

P3 Public-Private Partnership

PACE Property Assessed Clean Energy

PDM FEMA Pre-Disaster Mitigation Grant Program

PICA, by its Spanish acronym Four Year Investment Program

PMO Puerto Rico Permits Management Office

PPA Power Purchase Agreement

PR Science Trust Puerto Rico Science, Technology & Research Trust

PRASA Puerto Rico Aqueduct and Sewer Authority

PRBA Puerto Rico Bankers Association

PRBC Puerto Rico Building Code

PRCC Puerto Rico Chamber of Commerce

PRDA Puerto Rico Department of Agriculture

PRDE Puerto Rico Department of Education

PRDF Puerto Rico Department of the Family

PRDHe Puerto Rico Department of Health

PRDHo Puerto Rico Department of Housing

PRDOJ Puerto Rico Department of Justice

PRDPS Puerto Rico Department of Public Safety

PREC Puerto Rico Energy Commission

PREMA Puerto Rico Emergency Management Agency

PREPA Puerto Rico Electric Power Authority

PRFN Puerto Rico Funders Network

PRHBA Puerto Rico Home Builders Association

PRHFA Puerto Rico Housing Finance Authority

PRHIA Puerto Rico Health Insurance Administration

PRHTA Puerto Rico Highways and Transportation Authority

PRIDCO Puerto Rico Industrial Development Company

PRIFA Puerto Rico Infrastructure Finance Authority

PRITA Puerto Rico Integrated Transit Authority

PRMA Puerto Rico Manufacturers Association

PRPA Puerto Rico Ports Authority

PRPB Puerto Rico Planning Board

PRPBA Puerto Rico Public Buildings Authority

PRPS Puerto Rican Planning Society

PRTC Puerto Rico Tourism Company

PRTD Puerto Rico Treasury Department

PRTEC Puerto Rico Trade and Export Company

PSHSB Public Safety and Homeland Security Bureau

QCEW Quarterly Census of Employment and Ways

RFP Request for Proposal

RISE Resiliency Innovations for a Stronger Economy

RPS Renewable Portfolio Standard

SAIDI System Average Interruption Duration Index

SAIFI System Average Interruption Frequency Index

SBA Small Business Administration

SMEs Small and Mid size Enterprises

SOPs Standard Operating Procedures

SSI Supplemental Security Income

SWMA Puerto Rico Solid Waste Management Authority

TIP Transportation Improvement Program

TRB Puerto Rico Telecommunications Regulatory Board

U.S. Army United States Department of the Army

UPR University of Puerto Rico

URA Puerto Rico United Retailers Association

USAC Universal Service Administrative Company

USACE United States Army Corps of Engineers

USDA United States Department of Agriculture

USDOC United States Department of Commerce

USDOED United States Department of Education

USDOL United States Department of Labor

USDOT United States Department of Transportation

USF Universal Service Fund

USFS United States Forest Service

USFWS United States Fish and Wildlife Service

USGS United States Geological Survey

WIOA Workforce Innovation and Opportunity Act

WPSs Water Pump Stations

WTPs Water Treatment Plants

WWPSs Wastewater Pump Stations

WWTPs Wastewater Treatment Plants

Santa Isabel, PR. Angel Xavier Viera-Vargas

01 BACKGROUND

Cayey, PR. Félix Aponte González

Puerto Rico Background

Hurricanes Irma and María impacted Puerto Rico on September 2017 and caused nearly complete devastation to the Island. On September 6th, Hurricane Irma, a category five storm, skirted the northern part of the Island, causing significant flooding and leaving more than 1 million people without electric power. Two weeks later, on September 20th, Hurricane María, the tenth most intense Atlantic hurricane on record, passed east-to-west across the whole Island. Hurricane María left the entire Island without electricity, and it damaged thousands of housing units, as well as telecommunication towers, roads, bridges, schools, and 80% of the Island's crop value. Furthermore, Hurricane María impacted the physical structure of all hospitals and health clinics, affected 70% of Puerto Rico's potable water treatment and distribution system, and caused immense suffering to all Puerto Ricans. The Government of Puerto Rico's damage assessment estimated that the Island would need $94.4 billion to fully recover[1]. The National Oceanic and Atmospheric Administration estimates the damage from María makes it the third costliest hurricane in U.S. history, behind Katrina (2005) and Harvey (2017)[2].

The severity of the impacts highlighted the Island's physical and natural infrastructure vulnerability to extreme weather events and the need to better prepare for future events. The hurricanes also exposed structural socioeconomic weaknesses that existed prior to the storms and that exacerbated their impacts, among them a contracting economy, a bankrupt public sector, declining jobs, high inequality, aging infrastructure, and continuous population loss.

The combination of these physical, natural, and socioeconomic factors tested Puerto Rico's resilience. Resilience is understood as the capacity to respond, survive, adapt, and grow in response to shocks and stresses. Shocks are major crisis events that disrupt the normal operation of communities, as well as their institutions and systems. On the other hand, stresses are chronic conditions that progressively reduce the ability of individuals, businesses, institutions, and systems to function effectively.

Hurricanes Irma and María, however, were only the latest of a series of significant events that have severely affected Puerto Rico over the last decade. The Island has faced multiple environmental and socioeconomic shocks that have tested its capacity and eroded its ability to respond resiliently in the past. Tropical cyclones, floods, and wildfires have been common occurrences in the Island's territory of roughly 9,000 square kilometers.

Also, Puerto Rico's economy has been suffering a staggering contraction for over ten years. The outward migration has resulted in a decrease in population of nearly 388,000 residents, or 10%, from April 2010 to July 2017[3]. Changing demographic patterns have resulted in reductions in the Island's[4] overall population, and in an increase in the elderly and the islanders


Patillas, PR. Andrea Booher

living below poverty levels. Over 41% of Puerto Rico's inhabitants are living below the U.S. federal poverty line, proportionally more than triple the U.S. average (11%)[5]. Puerto Rico's GINI coefficient, an indicator that denotes income inequalities across populations, is the highest in the United States[6].

Moreover, in May 2017, a fiscal crisis that developed over decades spurred a bankruptcy declaration by the Government of Puerto Rico and several of its public corporations. The bankruptcy declaration[7] prompted a process to restructure Puerto Rico's debt obligations, placing additional challenges on its public sector operations and services. As such, any recovery measures that require changes to the budget of Puerto Rico government agencies (from either the revenue or expenditures), could be subject to additional restrictions by the U.S. Federal Court and the Financial Oversight and Management Board for Puerto Rico. All these factors constitute stresses affecting Puerto Rico, and they create additional challenges to the overall management of local government agencies and their policy implementation processes.

Even in the midst of all this turmoil, Puerto Ricans are clear on one thing: The path forward is not to return the Island to its prior state, normality is not the goal. The story of the new Puerto Rico is yet to be written. The Island must use this catastrophe to leverage the investments that will be made to change its growth and development trajectory. The recovery process should not focus salely on replacing outdated infrastructure. Instead, it should aim at building better assets, unleashing innovation, and coordinating among interested stakeholders. By creating these conditions, the path to address multiple challenges, increase social cohesion, strengthen the economy, and eliminate existing underlying socioeconomic weaknesses will be paved. Only then, Puerto Rico will be a better place for its citizens. This is the vision of the Resilient Puerto Rico Advisory Commission and its core project, ReImagina Puerto Rico.

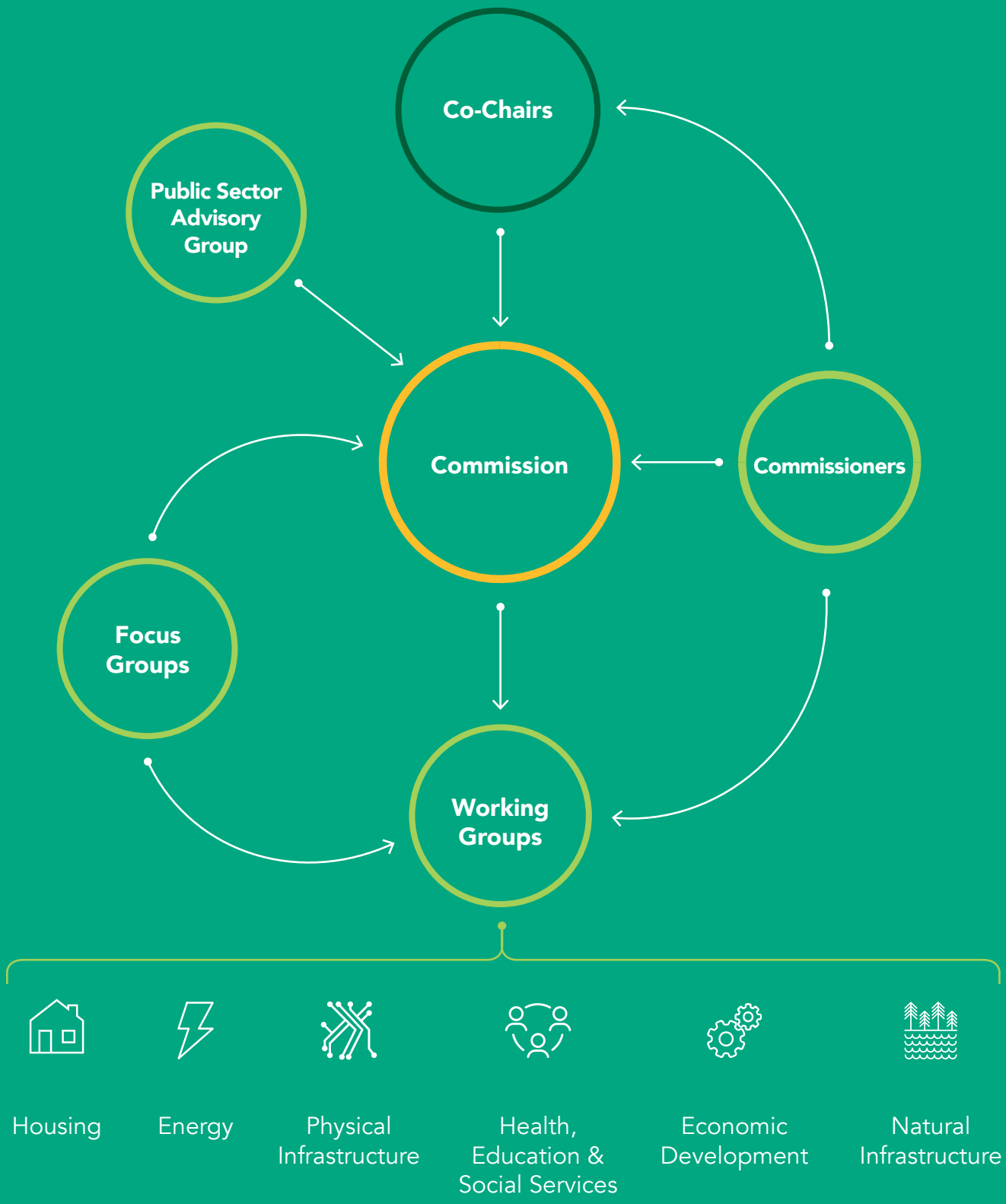
About the Resilient Puerto Rico Advisory Commission

The Resilient Puerto Rico Advisory Commission (the "Commission") was created in November 2017 as an independent, inclusive, non-partisan and, non-governmental, body led by Puerto Ricans. It is designed to serve as a unifying force among a diverse group of voices.

The Commission is chaired by five Co-Chairs and has 22 Commissioners. The Co-Chairs are leaders from Puerto Rican civil society that represent diverse interests and social sectors. They were selected in consultation with local groups to lead the effort and evaluate, endorse, and approve the overarching recommendations of the Commission's reports. Commissioners are civic, community, and business leaders appointed by the Co-Chairs, and they represent a broad cross-section of NGOs and academic, civic, and professional communities in Puerto Rico. They are the project's ambassadors, an integral part of the community engagement, and have contributed their knowledge and technical expertise to the development of this report's recommendations.

The Commission's goal is to promote a more resilient Puerto Rico as part of a long-term reconstruction process that improves Puerto Ricans' quality of life. It envisions a more participatory and transparent recovery process where the people of Puerto Rico take an active role in forging the future of the Island.

F1 RESILIENT PUERTO RICO ADVISORY COMMISSION ORGANIZATIONAL CHART



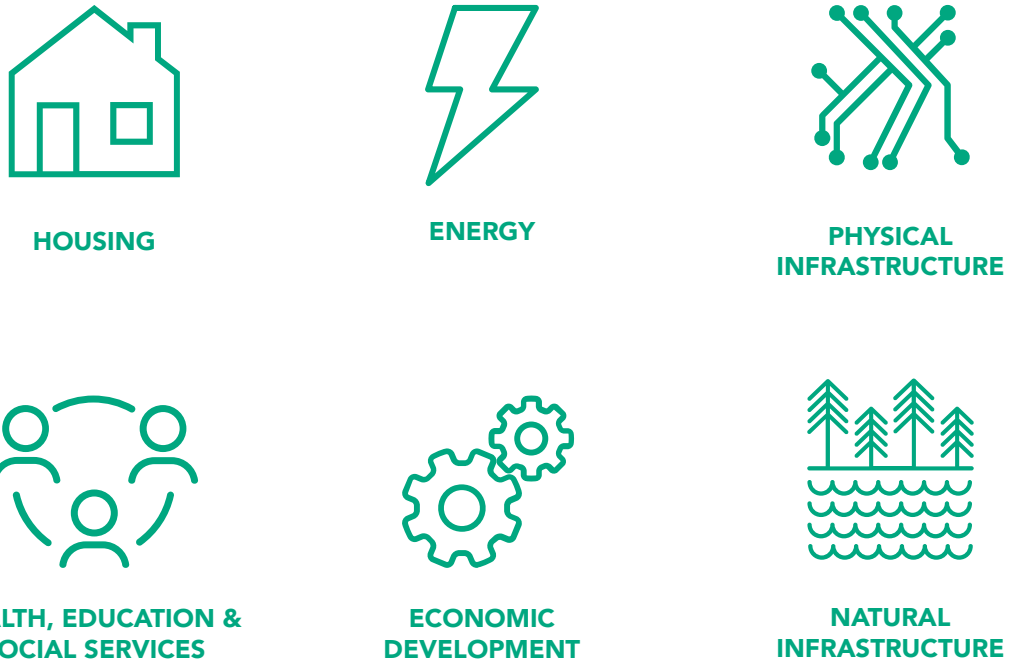
The Commission receives no public funding. It is financially supported entirely by **Ford Foundation**, **Open Society Foundations**, and **The Rockefeller Foundation**, with technical support from The Rockefeller Foundation's 100 Resilient Cities, as part of a broad effort to support the resilient recovery of Puerto Rico.

The Commission's core project, ReImagina Puerto Rico, aims to:

Produce an actionable and timely set of recommendations for how to use philanthropic, local government, and federal recovery funds to help rebuild Puerto Rico in a way that makes the Island stronger –physically, economically, and socially– and better prepared to confront future challenges.

San Juan, PR. Han Kim

F2 WORKING GROUPS



The Commission embarked on a broad, participatory process to achieve this objective, and it focused its analysis on several key sectors, organized under six working groups (see Figure 2).

Working groups met on three different occasions with approximately 15-20 individuals per working group meeting. They included commissioners and other experts and stakeholders with knowledge and expertise within the scope of the working groups. The three working group sessions led to the identification and development of each sector's goal and sector-specific recovery recommendations for Puerto Rico's resilient rebuild (see Methodological Approach on Appendix). Technical discussions within working group meetings were also nourished through a Community Outreach and Engagement Process that was held across Puerto Rican communities to validate and strengthen the identification of unmet needs, sector goals, and recovery actions.

One of the core distinctions of this effort lies in the broad and participatory outreach approach it has adopted towards Puerto Rico's recovery and reconstruction. The Commission has placed a central focus on enabling a conversation among diverse voices to build consensus and identify opportunities to embed resilience in the rebuilding efforts. As part of the project's Community Outreach and Engagement Process, ReImagina Puerto Rico brought together community members and leaders, grassroots organizations, business leaders, government officials, representatives from professional organizations, and students, among other groups. ReImagina Puerto Rico interacted with more than 750 individuals throughout the engagement process, including representatives from the Puerto Rican diaspora in Central Florida. Furthermore, it provided a common platform to discuss concerns and aspirations regarding a more resilient Puerto Rico. The extensive input gathered throughout this outreach process strongly shaped the development of the recommendations described in this report.

Finding the Path Forward

The Commission's primary focus was to develop recommended actions with resilience qualities such as being inclusive, integrated, flexible, redundant, reflective, resourceful, and robust and targeting issues of equity, transparency, and sustainability. The process of rebuilding Puerto Rico offers the opportunity to address some of the underlying challenges that have prevented Puerto Rico from overcoming most recent disasters.

Building resilience requires looking at a community holistically and understanding the systems that make up the place, as well as the interdependencies and risks, through precise identification of existing and potential shocks and stresses. Beyond continuing to build its capacity for resilience, Puerto Rico needs to take advantage of the current moment to embark on a unified planning exercise that emanates from a series of consultations and debates with numerous stakeholders and at multiple scales. Such a planning exercise can help strengthen Puerto Rico's social fabric, as well as help devise and design a more precise set of projects and programs that can improve its development trajectory and the well-being of its citizens. To help jumpstart the required planning efforts, ReImagina Puerto Rico has put forth specific and actionable recommendations that comprehensively, and in a coordinated manner, address unmet needs, ongoing challenges, and mitigate the impact of future disasters.

San Juan, PR. Prayitno

Working Group Mission and Approach

The mission of the Physical Infrastructure Working Group was to evaluate and prioritize critical infrastructure needs, identify best practice recommendations to address these needs, and leverage and enhance existing organizational frameworks to build resilience across all of Puerto Rico's infrastructure assets.

The Physical Infrastructure Working Group served as an advisory group to the Commission and provided valuable input on issues related to the recovery, accessibility, and delivery of the critical physical infrastructure services in Puerto Rico. Potential financing sources for the Commission's recommendations were identified in order to further support these efforts. The Working Group focused on critical infrastructure systems, assets, and services provided by public and private agencies.

Such debilitating impacts created a sense of uncertainty and insecurity across the Island's communities. Acknowledging the hazards, vulnerability, and exposure that define the hurricanes' levels of impact, the Physical Infrastructure Working Group identified key considerations to build resilient physical infrastructure for the Island. These considerations include establishing an island-wide mitigation plan to reduce threats from acute events, developing a preparedness and emergency response plan, and identifying and supporting on-going recovery efforts in the short, medium, and long-term. In addition to identifying resilience strategies for the Island, its communities, and its residents, there is a need to address social equity concerns and prioritize vulnerable and historically underserved populations throughout infrastructure recovery and rebuilding efforts. Based on their experience, the working group members assessed available information, secondary data, and critical infrastructure vulnerabilities. They emphasized telecommunications, transportation, water infrastructures, and decentralized basic infrastructures at the community level.

The following sections provide an overview of pre- and post-hurricane conditions of Puerto Rico's critical infrastructure based on local communities and the telecommunications, transportation, and water sectors. Sector-specific unmet needs that pose opportunities and actionable direction for next steps were also identified.

02 SECTOR CONTEXT

San Juan, PR. Lorie Shaull

Pre- and Post-Disaster Conditions

The Physical Infrastructure Working Group mainly looked into physical infrastructure assets, systems, and networks required for the society and economy to subsist, function, recover, survive, and thrive. Such structures and systems include health systems, flood protection systems, communications infrastructure, transportation networks, the power grid, and sewage and waste disposal systems. Recommended actions focus on strengthening the resilience of the physical infrastructure needed to sustain and deliver critical operations during a disaster event and promote transformation. The Commission characterized the physical infrastructure in three levels:

B. Critical Infrastructure Sectors: Sector-specific infrastructure that is essential to withstand and rapidly recover from hazards. Telecommunications, transportation, and water were identified as the three primary sectors.

A. Critical Infrastructure Systems: Infrastructure systems and interdependent functions needed to sustain and deliver critical operations.

C. Place-based Infrastructure: Decentralized systems that provide critical services at the community level.

A. Critical Infrastructure Systems

Critical infrastructure enables the provision of essential services. The United States Department of Homeland Security (DHS) asserts that "critical infrastructure represents systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters[8]."According to the above definition, critical infrastructure comprises infrastructure and facilities that are essential for the subsistence of individuals, communities, and society; maintains socio-economic progress; and increases the recovery capacity of ecosystems. DHS defines 16 critical infrastructure sectors. Examples of critical infrastructure include hospitals, telecommunications networks, highways, police stations, power stations, water treatment plants, flood protection infrastructure, airports, and marine ports.

Ensuring continued operation of the Island's critical infrastructure is essential to strengthen the capacity of Puerto Rico to survive, adapt, and thrive after a disaster. For this reason, critical infrastructure must be able to withstand and rapidly recover from hazards affecting Puerto Rico. Therefore, proactive and coordinated efforts are necessary to strengthen critical assets, networks, and systems that are vital for the well-being and prosperity of Puerto Rican society. These efforts result in more resilient, secure, and functional critical infrastructure. However, the Island's critical infrastructure is diverse and complex. It includes distributed networks, various organizational structures and operating models, interdependent functions, and physical and cyber domain systems[9]. An integrated planning approach centered on managing risks to individual operations and coordinating critical infrastructure interdependencies can help determine effective risk management strategies. Thus, there is also a need to improve coordination between capital investment, land use, and essential infrastructure planning.

DHS defines 16 Critical Infrastructure Sectors:

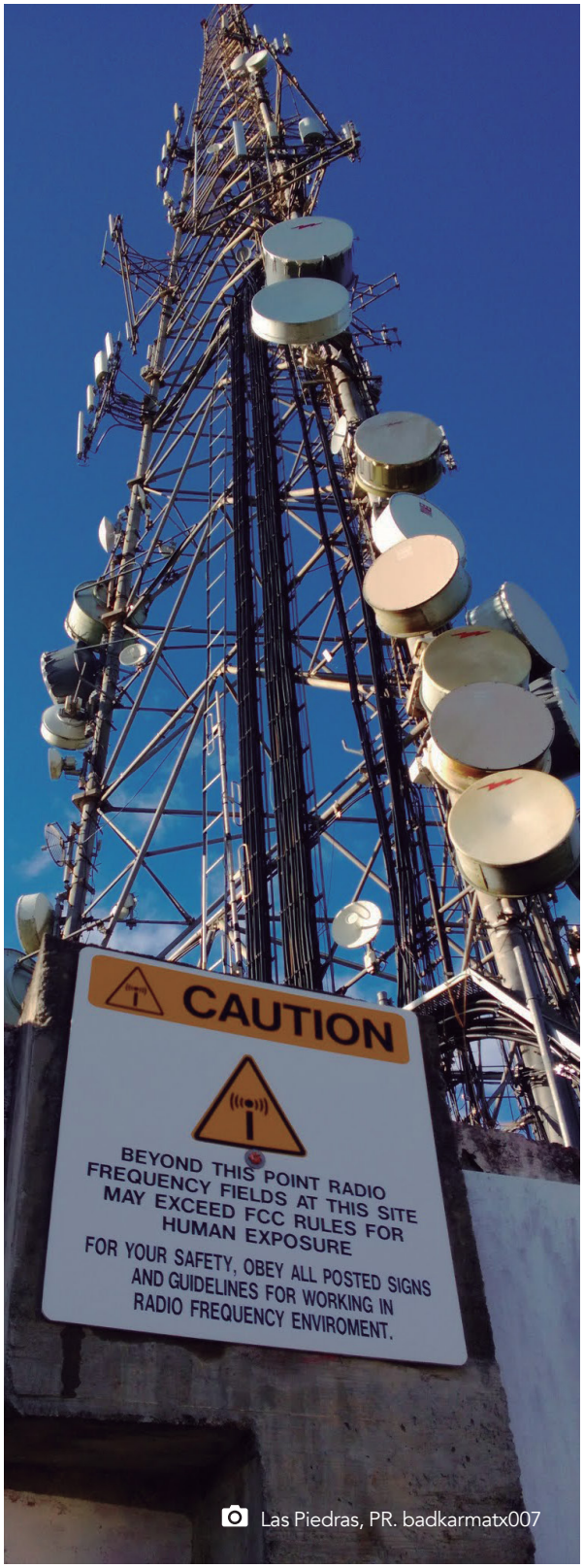
Actions to further ensure the security and resilience of critical infrastructure cannot be designed based on the traditional fragmented approach, where the focus is on individual infrastructure sectors and the codependency of critical assets, systems, and networks is overlooked. The aftermath of Hurricanes Irma and María reflected a lack of flexibility of assets and systems in responding to changing conditions. This caused problems to exacerbate and cascade from one infrastructure to another. Following Hurricane

María, emergency relief resources for communities and businesses were often delayed due to a lack of communication between the Puerto Rico Ports Authority (PRPA), the Puerto Rico Department of Transportation and Public Works (DTPW), the Federal Emergency Management Agency (FEMA), telecommunications providers (such as Claro and AT&T), and other emergency response teams. Disruptions in electricity and telecommunication services and faulty coordination between agencies and private actors caused delays in emergency response and relief efforts.

A vision that rethinks reconstruction efforts must recognize the dependencies and interdependencies of critical infrastructures, rather than looking at each component independently. Doing so would protect and sustain the likelihoods of Puerto Ricans. Dependencies are links or connections between two or more infrastructure systems through which the performance of one infrastructure system influences the performance of the other, for example, the electricity used to power telecommunications switches or stormwater pumps. Interdependencies refer to bi-directional relationships between two infrastructure systems through which the condition of each infrastructure influences the status of the other.

Puerto Rico reconstruction efforts should focus on critical infrastructure systems that provide equitable access to goods and services. They should also support communities, businesses, and government institutions so they may bounce back and recover from the shocks and stresses that the Island faces. Planning capacity to govern these infrastructure systems should be integrated at all levels in order to include individuals and communities. Actions presented to improve critical infrastructure are focused on addressing opportunities to incorporate planning, understand the role of providers, address gaps in the delivery of services (roads, bridges, ports, water and power providers, telecommunication companies, etc.), examine post-hurricane conditions and critical infrastructure interdependencies, and evaluate the capacity to address society's changing needs.

Maunabo, PR. José Oquendo



Las Piedras, PR. badkarmatx007

B. Critical Infrastructure Sectors

TELECOMMUNICATIONS AND DIGITAL INFRASTRUCTURE

In general, pre-hurricane Puerto Rico was well served with legacy wireline and wireless telecommunications services, including cable-based broadband, DSL, and 4G mobile service in most areas. Access to and adoption of telecommunications services was impacted by multiple factors, especially with low internet adoption rates common among low-income, seniors, and rural residents.

Pre-hurricane conditions were documented in detail in the Puerto Rico Broadband Strategic Plan[10] This plan was funded in 2009 by the National Telecommunications and Information Agency (NTIA) through the Broadband Technology Opportunities Program (BTOP) created under the American Recovery and Reinvestment Act (ARRA). In conjunction with the Broadband Strategic Plan, the Puerto Rico Broadband Taskforce (PRBT) was formed in 2011 with two key objectives: (1) to ascertain the size and scope of the digital divide in Puerto Rico and identify strategies to close it and (2) to steer public and private stakeholders across Puerto Rico and the U.S. to action regarding these recommendations. The PRBT is a non-governmental, public-private partnership, conceived by the Chief Information Officer of Puerto Rico, the President of the Telecommunications Regulatory Board, and the Internet Society of Puerto Rico, that joined forces to establish a nonpartisan committee that includes key stakeholders in the broadband ecosystem.

Connect Puerto Rico is another reliable source that serves as a subsidiary of Connected Nation,

The Gigabit Island Plan establishes an ambitious **vision for broadband** expansion across **Puerto Rico** **5** over the next years

This plan calls for **99%** of households to have access to broadband at speeds of at least **10 megabits per second (Mbps)** and **70%** of households to have **access at speeds of one gigabits per second (Gbps)** by the end of the decade

and it operates as a nonprofit entity in Puerto Rico. Connect Puerto Rico also supported the PRBT in preparing the Broadband Strategic Plan[11] by providing research and analysis consulting services. The PRBT believes that it is imperative for Puerto Rico's economic sustainability to aggressively join the ranks of the gigabit community. Fueled by this belief, the Gigabit Island Plan establishes an ambitious vision for broadband expansion across Puerto Rico over the next five years. The Gigabit Island Plan calls for 99% of households to have access to broadband at speeds of at least 10 megabits per second(Mbps) and 70% of households to have access at speeds of one gigabit per second (Gbps) by the end of the decade. To help meet these goals, the Gigabit Island Plan builds upon the 2012 Broadband Strategic Plan, evaluates Puerto Rico's current broadband landscape and trajectory over the last five years, and proposes revised and new strategic policy recommendations for continued expansion of both public and private broadband network investment. The Gigabit Island Plan also encourages expansion of broadband adoption and use among Puerto Ricans that remain disconnected. Additionally, expanding gigabit connectivity to all schools accross the Island will benefit schools by providing them access to online resources and connectivity.

Since the release of the 2012 Broadband Strategic Plan, the private sector has significantly invested in broadband infrastructure across Puerto Rico. As of June 2014, 77.8% of households had access to broadband of at least 10 Mbps download and 1.5 Mbps upload speeds, up from only 24.5% in 2011. Moreover, whereas no household had broadband available at speeds of 100 Mbps in 2011, by June of 2014 52.9% of households had access at that speed. Further, 99.9% of households have access to mobile broadband speeds of at least 3 Mbps download and 768 Kbps upload[12].

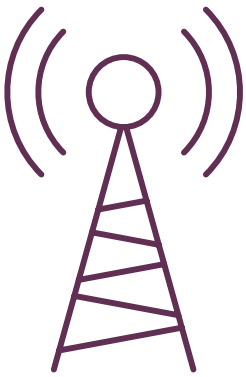
Additional research, conducted by Connect Puerto Rico, found in 2015 that approximately 91% of the 1.38 million households had access to 3 Mbps broadband service, which left 126,000 households unserved when no gigabit level service was available. This research also estimated that 99.95% of Puerto Rico households had cellular connection, which was mainly because five mobile providers served the Island. Furthermore, one of two cable television providers served 77% of households, and 85% of the 844,000 rural households had access to fixed broadband service (cable and mobile) while 99% had internet access through terrestrial service. Despite access, research has shown that all telecommunications services are dependent on electricity in order to have access to broadband, cellular, and cable connections[13].

The Federal Communications Commission (FCC) incorporates network outage data submitted by communications providers to the FCC's Disaster Information Reporting System (DIRS). DIRS is currently activated for all counties in Puerto Rico and the U.S. Virgin Islands, and it comprises the information into a weekly damage assessment report which shows immediate and recovery impacts from the hurricanes. According to the FCC Hurricane María Status Report of September 20, 2017, 95.2% of cellular towers were nonoperational (1,703 of 1,789). Furthermore, 48 of the 78 municipalities of Puerto Rico sustained 100% loss of cell tower functionality, and all 78 municipalities sustained more than 75% loss of cell tower service. Cable television service was largely disrupted by the lack of electricity and the destruction of aerial cables on utility poles. According to the Tele Geography Submarine Cable Map 2018, the Island is served by 19 maritime (underwater) cables, which are laid on the seabed between land-based stations to carry telecommunication signals across stretches of ocean and sea. The storms did not damage any maritime cables, and there was no significant damage to cable headend sites, which serve as master facilities for receiving television signals to process and distribute cable television systems according to the FCC Hurricane Damage Assessments[14].

As of June 2014, **77.8%** of households had access to broadband of at least **10 Mbps download** and **1.5 Mbps upload speeds**, up from only **24.5%** in 2011

Hurricane María caused **95.2% of cellular** towers to be nonoperational **(1,703 of 1,789)**

99.9% of households have access to mobile broadband speeds of at least **3Mbps download and 768 Kbps upload**



Puerto Rico sustained **100%** loss of cell tower functionality in **48 municipalities** and more than **75%** **loss of cell tower service** in all 78 municipalities

San Juan, PR. Space toaster

TRANSPORTATION INFRASTRUCTURE

The multimodal transportation network in Puerto Rico is made up of a system of roads, highways, and transit and ferry services, along with bicycle and pedestrian facilities, all of which provide services to more than three million residents. In 2014, Puerto Rico's Governor signed Act 123-2014 to streamline the inter-agency transportation planning process and related inefficiencies. Act 123-2014 integrates all organizations under a central authority – Puerto Rico Integrated Transit Authority (ATI). The integration included transferring Puerto Rico's Highway and Transportation Authority's (ACT) operations, rights, obligations, and related assets to ATI. The other main agency assigned to ATI was the Metropolitan Bus Authority (AMA)[15].

When Puerto Rico's Act 123-2014 was introduced, the Island's public institutions were already facing financial struggles and a combined debt that reached $74 billion. These financial struggles affected Puerto Rico's ability to receive federal transportation funding. In part, this occurred due to Puerto Rico's long-standing fiscal and economic situation, during which the Government of Puerto Rico and municipalities were often unable to provide the necessary 20% minimum local match funding to receive federal dollars for transportation projects. Most of the requested funds were intended for infrastructure improvements of crumbling roadways, collapsed bus terminals, and other deteriorating infrastructure noticeably present across Puerto Rico.

In May 2017, Puerto Rico filed for bankruptcy under the Puerto Rico Oversight, Management, and Economic Stability Act (PROMESA) Title III. The Bank of New York Mellon Corp serves as the trustee for bonds issued by PROMESA. However, PROMESA instructed the bank not to cover a forthcoming bond payment, since the agency wanted to retain the funds as it works through bankruptcy proceedings to reduce its debt. PROMESA has approximately $4 billion of debt, and at least one large holder of these highway bonds is suing Puerto Rico to stop them from redirecting toll revenue away from bondholders, but the court denied the preliminary injunction[16] [17].

At the end of the storm on September 21, 2017, only the Luis Muñoz Marín International Airport, in San Juan, **was able to operate a few dozen flights daily**

At the same time, the Puerto Rico Department of Transportation and Public Works (DTPW) released Amendment #1 of the Transportation Improvement Program (TIP), with a particular focus on urbanized areas, for Fiscal Years 2017-2020. This amendment was prepared in accordance with the requirements of the Moving Ahead for Progress in the 21st Century Act (MAP-21) funding surface transportation programs, and it presents proposed improvements to the transportation and highway systems of Puerto Rico for a period of four fiscal years. This TIP amendment covers transportation programs and projects totaling approximately $58.1 million over four years[18].

Credit ratings across all sectors in Puerto Rico were downgraded following Hurricane María. Moody's Investors Service, a bond credit rating business, estimates Puerto Rico reduced its debt serving capacity due to damage from natural causes. The consequences of credit ratings downgrade included specific impacts on Puerto Rico transportation entities. The Puerto Rico Highways and Transportation Authority bonds issued under the 1968 Resolution (the Highway Revenue bonds) were specifically downgraded from Ca to C[19]. Compared to U.S. States like Texas and Florida, Puerto Rico has faced – and continues to face – considerably more challenges in receiving recovery support due to the political, financial, and logistical challenges of delivering aid to the Island.

As Hurricanes Irma and María were the strongest storms to hit the Island in more than 80 years, losses to transportation infrastructure were recorded across all modes and sectors. Heavy rain and winds carpeted roadways with debris, knocked out the electrical grid and cell towers, and destroyed clean water sources and other important infrastructure. Gasoline supplies became depleted, and roughly two-thirds of the gas stations were closed because of the storm, which limited mobility of residents across the Island due to a strong reliance on personal automobiles. The air traffic control system was also significantly damaged during the storm, and, a week after Hurricane María, Federal Aviation Administration crews continued to repair radar units, navigational aids, and other equipment, in seven of the eight commercial airports, all of which were operating on very limited capacity. At the end of the storm on September 21, 2017, only the Luis Muñoz Marín International Airport in San Juan was able to operate a few dozen flights daily[20].

The disaster also demonstrated the vulnerabilities of Puerto Rico's ports and its operations, especially the critical ports in San Juan and Yabucoa. These ports suffered both physical damage and disruption of operations, making it difficult for Puerto Ricans to receive equipment and resources for the recovery and essential goods (i.e., food, medicines, and batteries). Also, these disruptions caused a cascade of effects on critical locations by limiting the availability, distribution, and management of diesel, which was used to operate trucks, construction equipment and auxiliary generators. Auxiliary generators were particularly necessary to power hospitals, treatment plants, storm water pumps, communication towers and nursing homes.

Shortly after the hurricanes, Puerto Rico's Secretary of the DTPW shared a preliminary estimate of damage of $240 million. DTPW Secretary also acknowledged that not all damages were accounted for, as information was not available for all roadways. Eight hundred incidents were recorded after Hurricane Irma, with an additional 1,500 cases of damaged or destroyed transportation infrastructure recorded after Hurricane María, which do not include broken traffic lights[21].

Since then, the following actions have supported the recovery efforts and repair of transportation infrastructure on the Island:

The Federal Highway Administration (FHWA) allocated a total of $72.5 million in "quick release" Emergency Relief funds: an initial $2.5 million after Hurricane Irma, another $40 million immediately after Hurricane María, and an additional $30 million in late November. These funds were explicitly allocated to begin the repair process of critical roadways and bridges across the Island[22] [23]. As of November 3, 2017, 2,932 miles of the 5,073 miles of roads were open to allow passage through the outer roads of the Island. Additionally, 88% of gas stations (970 of 1,100) reopened as of December 26, 2017[24].

The Federal Aviation Administration (FAA) immediately supported the restoration of services to most of the commercial airports in Puerto Rico. The FAA also restored full air traffic control service to the Luis Muñoz Marín International Airport and worked to restore radars, navigational aids, and other damaged equipment in order to increase the number of flights that could arrive and depart the Island[25]. As of April 2018, all airports are open or open with restrictions[26].

The Federal Transit Administration (FTA) awarded $8.4 million in critical grant funding to Puerto Rico to support the Island's transit systems[27]. As of December 29, 2017, all bus routes from the Metropolitan Bus Authority (AMA for its Spanish acronym) were operational[28].

The Maritime Administration provided vessels to deliver power, food, clean water, and provide berthing for first responders in order to free up hotels for displaced residents[29]. All ports, including container ship ports, have been reopened[30].

On September 28, 2017, the U.S. President temporarily waived the Jones Act to allow foreign ships that were coming from U.S. ports to dock in Puerto Rico and deliver supplies, as was previously done for Florida and Texas. The Jones Act increases shipping costs to Puerto Rico and other non-continental U.S. lands that rely on imports, because it limits the number of ships that can legally deliver goods, and it does not allow foreign ships to dock in Puerto Rico if they plan to continue to the mainland and deliver goods there[31].

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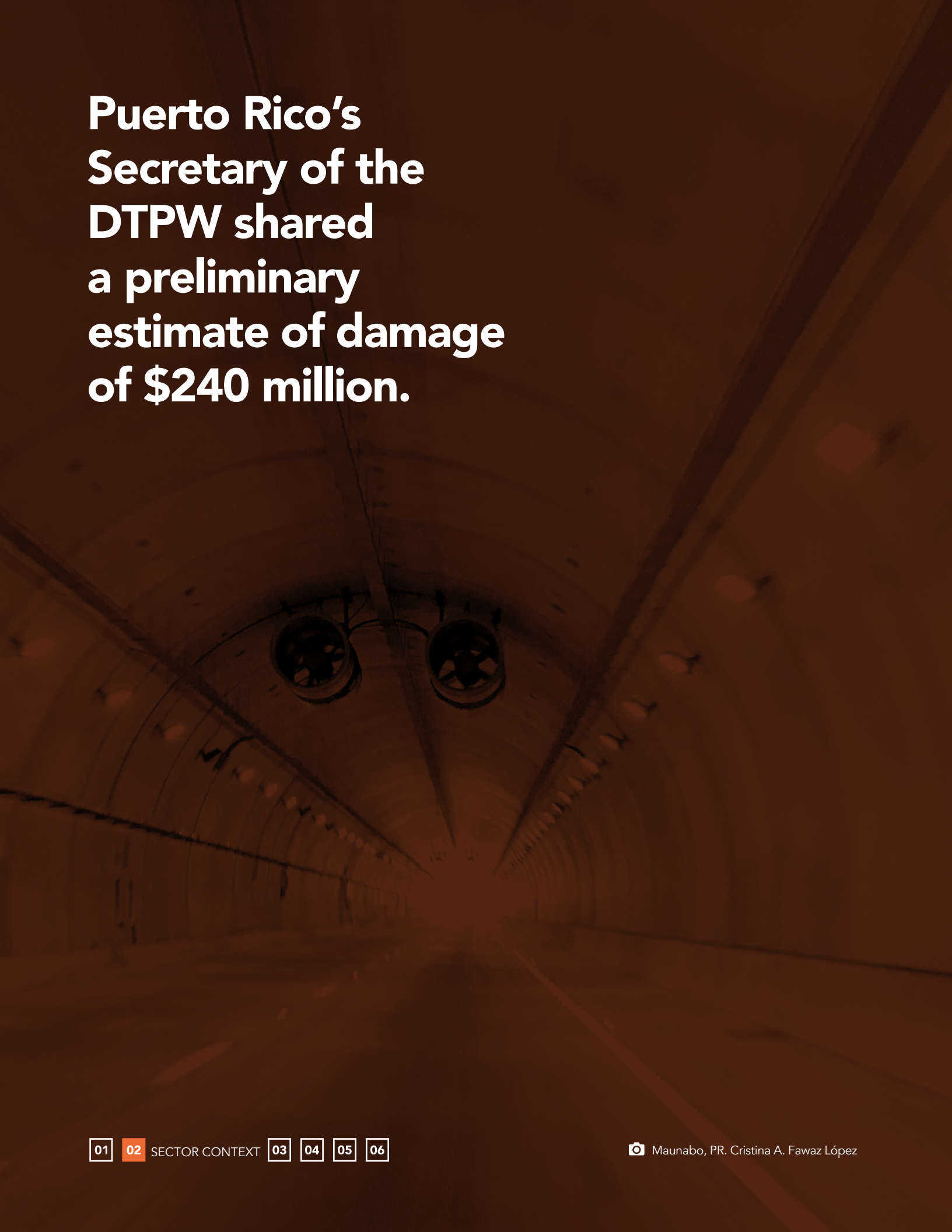

Maunabo, PR. Cristina A. Fawaz López

WATER AND WASTEWATER INFRASTRUCTURE

The Puerto Rico Aqueduct and Sewer Authority (PRASA) is the only water and wastewater utility in Puerto Rico. PRASA provides potable water and wastewater services to about 97% and 59% of Puerto Rico's population, respectively. PRASA is a critical entity for the well-being of Puerto Rico, and its effective operation and high performance is essential to the health and economic prosperity of Puerto Rico and its citizens. PRASA is a public corporation of the Government of Puerto Rico, and it is responsible for providing water and sewerage services to the Island's population since 1945. PRASA serves a population of approximately 3.47 million residents[32], in addition to approximately 5 million annual visitors. It produces over 557 million gallons of potable water per day, but, with non-revenue water remaining high at 57.8%, the current water supply system is highly inefficient. PRASA is organized into five operational regions (north, south, east, west, and metro), and it is managed by an executive management team that provides the day-to-day management oversight and coordination for all institutional activities.

Due to Puerto Rico's contextand its approximate area of 3,535 square miles, PRASA builds its supply concept on a fragmented and localized system of water sources and treatment and distribution infrastructure. This increases its vulnerability and contributes to higher operation and maintenance (O&M) costs. Thus, PRASA has many more treatment facilities than most utilities serving a similar number of customers. The proliferation of facilities results in more diversity in PRASA's assets, especially regarding size, treatment technologies, and age.

Based on data obtained from PRASA's FY 2015 Accountability Report, as of June 30, 2015, PRASA owns and operates eight dams, 118 water treatment plants (WTPs), 52 wastewater treatment plants (WWTPs), 269 wells, 954 water pump stations (WPSs), 1,486 water storage tanks, 824 wastewater pump stations (WWPSs), six ocean outfalls, and more than 20,000 miles of water and wastewater pipelines Island-wide. However, as of September 30, 2015, with the elimination of La Máquina WTP and Alturas de Orocovis WWTP (Consent Decree Certification Civil Action No. 06-6624), the total number of WTPs and WWTPs in operation is currently 117 and 51, respectively.

Raw water, used to produce drinking water in Puerto Rico, comes from two primary sources: groundwater and surface water. Groundwater is typically pumped from wells and distributed to consumers with little or no treatment. Surface water mainly comes from reservoirs and is conveyed to treatment facilities before being distributed. Reservoirs provide most of the water supply in Puerto Rico. Most reservoirs were constructed in the early and mid-20th century, and sediment accumulation has significantly reduced their original storage capacity. The humid, tropical environment and mountainous terrain of Puerto Rico are conducive to high rates of sedimentation. Additionally, sediment washed from the hillslopes and construction sites, settles out in the calm waters of reservoirs, reducing the storage capacity and, eventually, ending their useful life. Major floods, associated with hurricanes and tropical disturbances, also cause extensive land erosion and sediment transport that rapidly deplete the storage capacity of reservoirs.

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PRASA serves approximately **3.47 million** residents

It produces over **557 million gallons** of potable water per day

PRASA OWNS AND OPERATES

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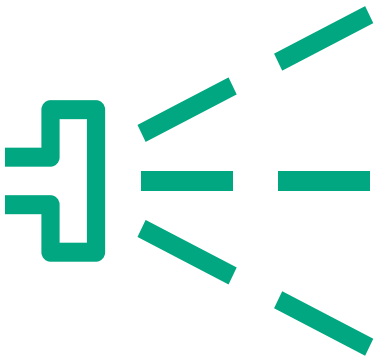
More than **20,000** miles of water and wastewater pipelines

The Puerto Rico Electric Power Authority operates three irrigation systems:

1. **Costa Sur** in the south
2. **Valle de Lajas** in the southeast
3. **Isabela** in the northwest



The Puerto Rico Electric Power Authority (PREPA) operates three irrigation systems: 1) Costa Sur in the south, 2) Valle de Lajas in the southeast, and 3) Isabela in the northwest. These irrigation systems convey water to agriculture sites, and to PRASA's treatment and distribution, thermoelectric power generation[34], and industrial irrigation systems. Some water demand, primarily in the heavy industrial and agricultural sectors, is met by independently operated wells, pumps, spring boxes, cisterns, and other similar technology used to harvest groundwater and surface water resources.

All regulated dams are under the jurisdiction of the Dam Safety Unit of PREPA. PREPA administers the Dam Safety Program in association with the Puerto Rico Department of Natural and Environmental Resources (DNER), Puerto Rico Planning Board (PRPB), PRASA, and public-sector appointees by the Governor. PREPA's Dam Safety Unit is resposible for performed inspections on seven PRASA regulated dams and creating summary reports addressing the dams' structures, pertinent works, operations, and safety. In 2016, a federal report from the Bureau of Reclamation warned of the vulnerability of the Lake Patillas dam, located near a geological fault. The Bureau pointed out that, if a strong earthquake occurs, this dam is susceptible to severe damage and would endanger nearby communities.

Lack of universal access to water has been one of the most impactful and difficult consequences Puerto Rico has faced after Hurricane María devastated the Island's infrastructure. Over 70% of Puerto Rico's drinking water system was affected by direct damages and the loss of power, resulting in widespread scarcity of potable water. Water provided through the public supply system was either unavailable or supplied in violation of federal safety and quality standards. In many areas, people were forced to obtain drinking water from unsanitary and untreated sources. To ensure safe drinking

Utuado, PR. Joshua DeMotts

water supply and avoid the spreading of diseases, potable water was distributed in containers and bottles. Despite PRASA's efforts to restore water supply, as of November 2017, five drinking water treatment plants remained out of service, and approximately 17% of those served by PRASA still had no access to water. Several weeks after due to the lack of electrical power service and a limited supply of generators and fuel, particularly diesel, PRASA was unable to purify water and treat wastewater in some of its facilities. At the beginning of January 2018, the situation substantially improved when PRASA achieved the installation of auxiliary generators in all its key facilities.

The Guajataca Dam, in northern Puerto Rico, had one of the most critical water system failures to occur as a result of the hurricanes. Due to heavy rains, the Guajataca Dam suffered a major breach in its emergency spillway. This breach exposed the dam to possible structural collapse and threatened hundreds of Island residents downstream. Damages to dams highly impacted the water supply situation in the western region of the Island, highlighting the need for increased redundancy and infrastructure resilience.

The pass of the hurricanes resulted in an uncontrolled release of untreated sand sewage water, as well as contaminated water, into the environment. This was caused by the existing system's issues with overflows. Debris from the storms clogged significant portions of the network, further damaging already weakened infrastructure, such as levee systems. As of November 2017, four PRASA wastewater treatment plants remained out of operation, all 13 of the levee systems were in need of reconstruction, and hundreds of stormwater drainage assets across the Island remained damaged, inoperable, and clogged with debris. Not only was the water infrastructure heavily impacted, but it also threatened public health and safety.

C. Place-based Infrastructure

As a response to the lack of access to potable water and waste collection systems in some areas of Puerto Rico, communities have adopted disorganized or unsystematic practices. In some cases, these practices created place-based infrastructures operated by members of communities in areas not served by distributed infrastructure. The provision of place-based infrastructure on the island has been in response to sprawling growth and lack of adequate access to critical services. These community-based solutions are recognized as part of Puerto Rico's physical infrastructure since they address underserved communities' necessities with adequate and affordable basic services, including waste management and water, sewer, and electric services.

Before Hurricane María, remote and underserved communities were suffering from limited access to reliable water, sanitary services, energy, health services, and effective communication. Three concerns were highlighted during the working group regarding critical services that were essential to the communities' recovery process after the impact of the hurricanes: potable water, sewer systems, and waste management. The limited access to health services for energy dependent individuals, the lack of communication to respond to the emergency, and the limited planning capacity intensified these challenges. Below, we review the pre-disaster community-based conditions of potable water, sewer systems, and waste management.

Community water systems serve 3% of the population in Puerto Rico that are not connected to PRASA. There are about 240 small, decentralized water systems[35], which are community or privately-run systems that supply water to people living mostly in rural, mountainous, and isolated areas of the Island. Collectively, they are known as "non-PRASA" systems. Non-PRASA systems produced approximately 7.0 MGD (million gallons per day) in 2010, according to estimates provided by the United States Geological Survey (USGS) and made up a relatively small portion of the water market[36]. Around 2013, the United States Environmental Protection Agency (EPA) estimated that 95% of non-PRASA systems had administrative orders for non-compliance with water quality standards, particularly regarding coliform bacteria and turbidity. The lack of financial sustainability, as well as the limited financial management capacity, of these community systems are reasons for the high level of non-compliance. Funding options for the improvement of these non-PRASA community systems seem to be very limited if not paid directly by the community. Most non-PRASA systems do not charge for water, and most of them do not have adequate (or any) funds to cover the

costs for compliance, repairs, maintenance, or capital improvements. In part, the lack of revenues is tied to both the inability and unwillingness of users to pay. With agriculture and farming as the main source of livelihood, water users in some of these remote and impoverished areas and communities have limited or no ability to pay for "traditional" water services. Also, there is a common cultural belief that water is a right and the users should not have to pay for it[37].

Hardly any of the systems seem to cover their operational costs. It is estimated that most operators are not paid employees but volunteers serving their communities. Non-PRASA systems serve communities of diverse sizes, ranging from less than 50 to 2,000 individuals. Most non-PRASA systems charge customers for the supplied water; however, tariffs seem to be randomly established rather than calculated to cover the cost. In most cases, consumers are charged a flat rate, varying between $5-$20 per month[38]. Additionally, most connections are not metered.

Communities that are not connected to PRASA's distribution and sewage network are served with smaller, independent, and mainly community run systems. Approximately 41% of the population is not connected to the sewerage network and disposes of wastewater through onsite sanitation solutions, septic tanks or constructed pluvial infrastructure.

Approximately
240
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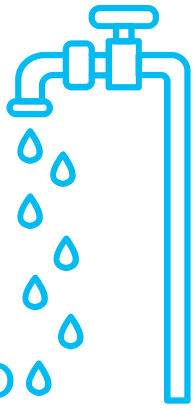
Puerto Rico



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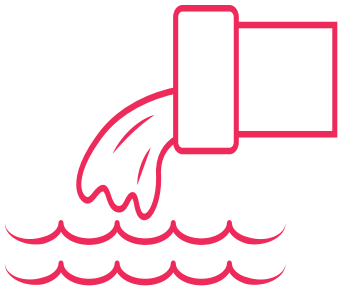

Urban and rural communities are experiencing informal solid dumping and river contamination due to lack of technical expertise, training, and treatment facilities. Lack of awareness of proper solid waste management (SWM) programs on the Island has led to the slow emergence of innovative, environmentally sound, sustainable solutions and the low prioritization of SWM programs. This informal solid-dumping practice is leading to acute environmental degradation and threats to public health, which are in turn constraining the future development of the Island and rural communities. The challenge for solid waste management is to adopt an integrated approach, including avoidance, recycling, minimization, treatment, and disposal. In many communities, shortage of skilled labor, and the lack of technical, economic, environmental and social criteria to deal with solid waste are enormous administrative and environmental problems. Usually, these communities receive few resources and lines of credit, which results in the inexistence of public sanitation programs. Therefore, the development of directives to guide adequate waste management and implement effective projects in accordance with environmental standards and sanitation sustainability is vital. The rising quantity of solid wastes and filling landfills, along with the growing concern of environmental quality, the health of the population and the lack of a suitable management model at the municipal governments, has led to the search for technologies that can meet a standard of economic, environmental, technical, and social sustainability. The active and cooperative participation of governmental offices, private initiatives, and civil society is essential.

During and after of Hurricane María, many communities suffered severe operational evacuation and response challenges. People living in flood zones and certain types of structures (e.g., wood houses) were urged by the government to evacuate and move to shelters. However, many people and families had to be rescued from flooding in multiple municipalities[39]. Based on preliminary observations from the National Institute of Standards and Technologies, emergency response challenges existed during and after the hurricane due to extended lack of communication between emergency response officials and the public, reliance on less efficient communication techniques, and recognized gaps in redundancy.

The aftermath of Hurricane María affected the provision of energy, water, health, and telecommunication services on the Island.[40] In the days after the hurricane, families were unable to contact each other for days and even weeks after the impact due to failures in power, communications and road infrastructure, which particularly affected vulnerable and remote communities. Also, 114 of the 237 non-PRASA drinking water systems were still inoperable over two months after the hurricane impact. Similar issues were experienced at the government level, as emergency response actions were severely affected due to failures in the electric power infrastructure, telecommunication services, and inaccessibility to hospitals. In response to the failure of the system to supply services effectively, local community centers became important gathering points where people went to seek shelter, receive aid, and participate in community events. These centers were transformed as temporary hubs for energy and water supply within the communities.

Waste management in Puerto Rico faced significant challenges as a result of the damage caused by Hurricanes Irma and María. The economy lacks diversity and market access, and management options are severely limited by the shortage and expense of available land. Burying wastes in island landfills is not a sustainable strategy for the long term. Also, because of the obstacles regarding access to national and international markets, it is essential to develop local reuse and recycling options for discarded materials. There is a need to develop an integrated solid waste management strategy for urban, rural, and remote communities in order to address challenges with diverse recommended actions. It will be important to address environmental burdens and liabilities caused by improper handling of solid waste and to develop programs that have the greatest potential to reduce the quantity of generated waste and increase recycling and composting.

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Shocks and Stresses

The Physical Infrastructure Working Group and participants of the community engagement process provided insights on their perceived short- and long-term shocks and stresses for Puerto Rico's infrastructure. The sustainable provision of telecommunications, water, wastewater, waste management, and flood protection systems were key areas of concern following the impacts of Hurricanes Irma and María. Additionally, the provision of coordinated transportation infrastructure proved critical for the mobility of residents, especially to reach hospitals, address damages to telecommunications, and to overcome challenges to the provision of goods and services in the Island. The working group identified the following shocks and stresses as having impacted the functionality of critical assets and services.

The main shocks include:

Hurricanes and tropical storms

Landslides and ground subsidence

Earthquakes and tsunamis

Floods

Swells resulting from winter storms

Heatwaves

Sustained winds (not related to storms or hurricanes)

Failure of health, communication, energy, fuel, and food distribution systems

The main stresses include:


Obsolete, deteriorated and aging infrastructure


Economic depression


Droughts


Increased in sea level


Coastal and riverine erosion


Sedimentation of water bodies


Climate change


Deforestation


Vulnerable population in high risk areas


Lack of preparation of individuals, communities, organizations and the government before extreme events


Limited government resources to meet essential needs and services


Violence and crime


Migration


Aging of the population and social insecurity for the retired

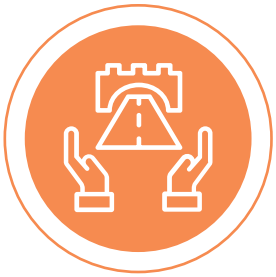

Losses of employment and closures of companies; unemployment and underemployment

Arecibo, PR. Raphaël Vinot

Unmet Needs

The following section summarizes the unmet needs that must be addressed throughout the recovery efforts in order to build a more resilient Puerto Rico. These needs were identified throughout the Physical Infrastructure Working Group meetings and the community engagement process:

LACK OF INTEGRATED PLANNING OF CRITICAL INFRASTRUCTURE. The lack of an integrated approach regarding interdependent critical infrastructures and combined services (a system of the systems) caused a cascading effect between different infrastructures, reducing the recovery capacity of the Island. Prioritization of assets is essential for the use of limited resources and develop realistic capital improvement plans effectively. Additionally, identifying critical infrastructure is essential to prevent large-scale system failures during extreme events. Asset vulnerability assessments should be prioritized based on exposure, sensitivity, and adaptive capacity. These assessments must also identify consequence of failure, remaining lifespan, and degree of exposure, as well as inform asset management and information kept in asset inventories.



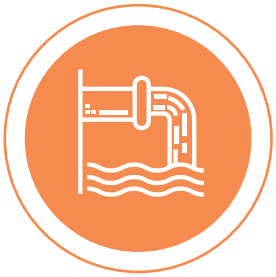
LIMITED PUBLIC PARTICIPATION IN INFRASTRUCTURE PLANNING. Communities expressed concerns regarding safe drinking water, failing dams and bridges, unfunded transportation systems, and access to reliable telecommunications and high-speed internet. Current public and private infrastructure planning and investment processes have limited involvement of interested stakeholders. Public participation in reconstruction projects will: support the prioritization of infrastructure investments for areas and communities with higher needs, promote stewardship and long-term viability, and improve transparency and accountability. These investments should create shared benefits and promote equity, environmental justice, and career and business opportunities.

LIMITATIONS FOR REDUNDANCY AND NEXT-GENERATION NETWORKS, INCLUDING COMPLEX PERMITTING AND CONSTRUCTION REGULATIONS. A resilient high-capacity, high-speed network is essential to all aspects of Puerto Rico's recovery. In addition to supporting the growing needs of the Internet of Things (IoT), a combination of wired and wireless infrastructure will provide redundancy and a range of capabilities to meet commercial, residential, and governmental needs. Telecommunications networks that cannot support IoT devices will either impact Puerto Rico's ability to adopt new technology or require additional infrastructure upgrades to be revisited later, which may include additional expenses. Expanded fiber-optic infrastructure, including greater redundancy of maritime cables, are essential to next-generation networks.

Revising the regulations that govern the permit application and make-ready processes can also significantly improve the time and cost of deploying and maintaining telecommunications infrastructure. These processes control who can place cables and other infrastructure in conduit, on poles, and in rights of way. There are best practices that can significantly reduce the time and expenses involved with applying for and processing permits, conducting pole and conduit surveys, and other essential tasks. Reviewing and revising telecommunications access regulations, applicable to Puerto Rico, will protect the safety and integrity of the telecommunications system, increase competition and ease of access, and make the network more resilient.

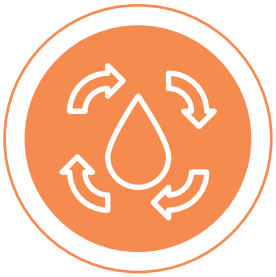
LACK OF RISK ASSESSMENTS AND INTEGRATED EMERGENCY AND CONTINGENCY PLANS FOR CRITICAL INFRASTRUCTURE. Hurricanes Irma and María caused greater impact due, largely, to the lack of updated risk assessments and adequate emergency and contingency planning. Careful planning can effectively diminish the impacts associated with extreme events and significantly reduce recovery time. An updated comprehensive assessment of the Island's exposure to flood risk is necessary to inform the reconstruction and upgrading of infrastructures. Base flood elevations and floodplains will need to be updated to ensure that all vulnerable assets are identified, and the resulted risks are clearly and accurately defined. Additionally, the consideration of climate change effects on future flood risk will help maximize the life of future projects. This aligns with other flood risk mitigation efforts, such as identifying areas that are vulnerable to coastal erosion, storm surges, or river flooding, and it ensures better flood protection to lower water treatment costs.

The effects and damages that occurred to physical infrastructure were island-wide, and they affected natural resources and ecosystems, building facilities, roads, and highways. As infrastructure providers (such as PRASA and DTPW) tackle rising costs and decreasing revenues, it will be necessary to make prudent choices regarding the placement of assets. Some assets that have been damaged and remain in vulnerable areas may need to be significantly improved by elevating electrical components and incorporating floodproofing measures. Therefore, it is crucial to identify areas where natural infrastructure can be incorporated to help mitigate the effects of flooding, storm surges, and coastal erosion on physical infrastructure.



INSUFFICIENT WASTEWATER TREATMENT. An upgrade of existing treatment plants (e.g., tertiary treatment) is needed to mitigate system overflows and improve effluent quality. System failures are frequent, and they threaten natural resources, as well as human health.

PARTIAL COMMUNITY PLANNING CAPACITY AND LACK OF COORDINATION. Communities are usually the first responders in the case of disaster events, especially following failure of critical services. Inadequate community planning and coordination often lead to response and recovery challenges due to lack of communication between individuals and officials and understanding of vulnerabilities. Therefore, adequate community planning that holistically engages the community, organizations, and institutions is imperative to strengthen individuals' capacity to cope with hazards, accelerate recovery, and minimize loss and damage to life, property, and the environment. Adequate community planning should include an analysis of communities' disaster risks (hazards, vulnerabilities, and perceptions of risk).



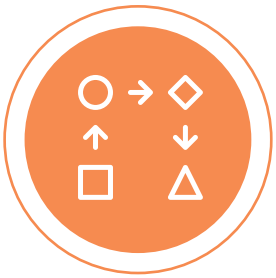
LACK OF SUSTAINABLE WATER RESOURCES. The working group identified water insecurity as a major problem throughout the Island, and, with climate change threatening to exacerbate water demand, contamination, and drought, the need for reliable water resources and sustainable and integrated management is pressing. A comprehensive assessment of existing and potential water resources is crucial in order to increase the resilience of water infrastructure and alleviate stress on existing groundwater and surface water sources.

LACK OF ACCESS TO CRITICAL GOODS, SERVICES, AND SAFETY DURING POST-DISASTER RECOVERY. In the aftermath of recent hurricanes, some communities across Puerto Rico were almost inaccessible for weeks. This was mainly due to collapsed roads and bridges, as well as blocked roads resulting from landslides, erosion, and strewn vegetation. There is a need to align more robust public safety protocols with the Island's emergency response operations and communications that provide greater access to emergency services. Consequently, this can ensure the safety of communities during major disasters in the future.

DERELICT AND VULNERABLE UTILITY AND FLOOD CONTROL INFRASTRUCTURE. Addressing obsolete infrastructure and reducing the vulnerability of critical assets, systems, and networks are key aspects for building resilient utility infrastructure systems for Puerto Rico. For example, several U.S. cities have recently advanced thinking on how to design and deploy utility conduit banks, sometimes referred to as utilidors, as part of their development of a smart utilities vision. Facilities that allow for shared use of limited rights can decrease costs and support easier deployments. This would increase competition and, ideally, reduce costs for consumers, while increasing network resilience. Understanding the specific costs and benefits of underground conduit, compared to new metal utility poles and other solutions, will be helpful in making informed decisions[42].

Damages to levees and dams throughout the Island increase the risk of flooding, impacting the lives and property of communities that depend on them. An assessment of the status, functionality, and required repairs is critical to prevent further damage to already devastated communities. Any assessment must be based on reliable climate projections and include the identification of priority interventions to ensure that climate change effects do not further degrade flood risk protection.

LIMITED FISCAL AND FINANCIAL CAPACITY TO FUND RECOVERY ACTIONS. Many government agencies that provide response and recovery functions did not have sufficient financial resources and capacity to fund response and recovery efforts. In particular, and as outlined in the post-hurricane context, many of the transportation, energy and water infrastructure agencies were not equipped or capable of receiving critical federal funding due to ongoing financial challenges on the Island. As such, the appropriate funding, financing mechanisms, and administrative support services need to be in place to support recovery actions.



INADEQUATE IMPLEMENTATION OF PLANNING AND ENFORCEMENT OF REGULATIONS. The U.S. Federal Emergency Management Agency (FEMA) identifies several forms of mitigation, including a focus on land use practices to minimize exposure to hazardous areas. The development of thoughtful and comprehensive land use planning and zoning codes, along with strict enforcement of existing and proposed development policies, can serve to minimize or mitigate the scale of future impacts. Issues regarding land use development are related to the provision of transportation infrastructure, such as roads, highways, and public transit, in appropriate locations. For example, development in areas susceptible to landslides or flooding has a direct impact on access to, but also on, the critical infrastructure itself.

IMPAIRED ASSET MANAGEMENT AND OPERATION OF CRITICAL INFRASTRUCTURE. An adequate asset management program is essential in order for utility infrastructure to address limited budget, deterioration of the assets base, population changes, and natural hazard uncertainties. The program comprises of systematic and coordinated activities and practices through which a utility optimally and sustainably manages its assets and asset systems and their associated performance, risks and expenditures over their life cycles in order to achieve more value with fewer resources[41]. Operation and management are key to improve system performance, minimize waste, and maximize cost-effectiveness. Some pertinent improvements include water quality monitoring, water safety planning, and the introduction of alternative and renewable energy sources, enhanced metering, and cost covering tariffs. Asset management provides a life cycle approach, which enables stakeholders (service providers, government, and individuals) to understand their asset systems and make long-term and environmentally concious choices.

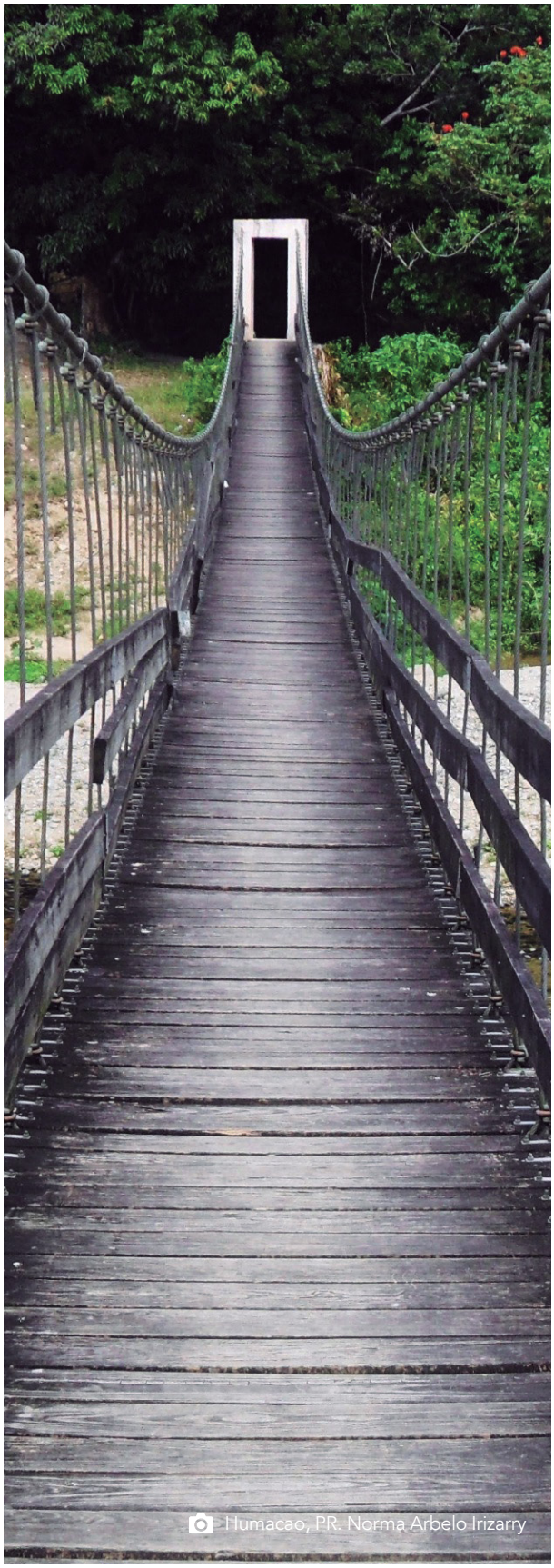
03 SECTOR GOAL

Trujillo Alto, PR. Mtmelendez

Develop and maintain infrastructure systems that are accessible, integrated, flexible, and robust enough so that they may sustain critical operations for the well-being of Puerto Ricans.

Accessible and resilient physical infrastructure will be the engine that drives economic growth in Puerto Rico, creating more opportunity and equity for its citizens. The actions presented are a roadmap for a resilient infrastructure that strengthens Puerto Rico's social, economic, ecological, and cultural well-being for present and future populations. Resilient infrastructure must be designed, constructed, operated, and maintained with the following key principles:

- The design, planning, and operation must be informed by an understanding of:
  - Diverse, dynamic hazards and the desired performance that correspond to each scenario.
  - Innovative solutions that allow for increased efficiency and effectiveness in addressing society's needs for present and future generations, along with the desired level of programmatic flexibility.
  - The systemic infrastructure interdependencies that impact the performance of assets, including power, water, transport, telecommunications, and material supply chains.
  - The systemic social and economic factors that impact the performance and success of an asset. These include community buy-in, the cost to the user, skills requirements for operating staff, availability of funding for operations, and maintenance.



Humacao, PR. Norma Arbelo Irizarry

- Planning and design processes should identify and maximize investment values on assets and systems, while minimizing negative social, economic, and environmental impacts.

- The consideration of co-benefits that might result in improvements to health, well-being, safety and security, environmental benefits, community cohesion, education and capacity building, economic development, and efficient use of water, energy, and other resources.

- Risk-based decision-making processes are necessary to ensure that projects are fit for purpose and that potential systemic impacts (positive or negative) are identified and maximized or minimized as needed.

- Manage critical infrastructure using a life-cycle approach that allows equitable distribution of all construction, operation, and maintenance costs among all the directly and indirectly benefited stakeholders.

- Stakeholder and community engagement is critical to develop an understanding of needs and positive and negative systemic impacts.

In the short- and mid-term, Puerto Rico has to focus on completing a comprehensive vulnerability assessment of all its critical infrastructures using the three levels presented in this report: systems, sectors, and place-based (decentralized). This assessment must be complemented with an understanding of societal needs that should be addressed in the short- and long-term of the reconstruction process.

This process should be followed by the implementation of projects based on the results and integrated with community-based solutions. The above initiatives will involve the following approaches, which are covered in the actions outlined in the Opportunity Actions detail:

- Prioritize projects in full compliance with regulatory and reliability requirements. They should be consistent with the customer, public health, and ecological needs.

- Provide reliable, responsive, and affordable services to the whole Island.

- Recruit and retain a workforce that is competent, motivated, adaptive, and safe-working.

- Establish a participatory and collaborative organization dedicated to continual learning and improvement. This would promote timely customer feedback, which should be used to provide prompt responsiveness to customer needs and emergencies.

- Understand the full life-cycle cost of the utility, and establish an effective balance between long-term debt, asset values, operation and maintenance expenditures, and operating revenues.

- Establish predictable and affordable investment rates that are adequate to recover costs, provide for reserves, maintain support from bond rating agencies, and plan and invest for future needs.

- Understand the condition of and costs associated with critical infrastructure assets. Maintain and enhance the conditions of all assets over the long-term at the lowest possible cost for its life-cycle and acceptable risk levels.

- Be cognizant of how infrastructure recovery decisions will impact present and future community welfare and environmental health. Manage operations, infrastructure, and investments as to protect, restore, and enhance the natural environment, water and energy resources, economic vitality, and the community.

- Consider a variety of pollution prevention approaches as part of an overall strategy to maintain and enhance ecological and community sustainability.

- Ensure critical service availability is consistent with current and future customer needs. This can be done through long-term resource supply, demand analysis, and public education.

Also, Puerto Rico's communities play an essential role in the reconstruction of the Island's critical service systems. Understanding, adapting, planning, and developing practices to compensate for the vulnerabilities above will ultimately save lives and dollars.

The actions are outlined under three physical infrastructure levels:

1

Critical Infrastructure Systems:
Infrastructure systems and interdependent functions needed to sustain and deliver critical operations

2

Critical Infrastructure Sectors:
Telecommunications, transportation, and water

3

Place-based Infrastructure:
Decentralized systems that provide critical services at the community level

Santa Isabel, PR. Angel Xavier Viera-Vargas

04 OPPORTUNITY ACTIONS

Ponce, PR. Roca Ruiz

Action Sheet Guideline

Action Number

Action Title

A1

Develop an Integrated Critical Infrastructure Management Strategy to guide resilient long-term reconstruction.

Description

A new vision for the reconstruction of Puerto Rico's infrastructure is critical for the Island's recovery. This recommendation envisions two main action areas: (1) an integrated infrastructure plan and (2) an infrastructure knowledge-based platform. Guided by the Puerto Rico Planning Board (PRPB), with active participation from Puerto Rico infrastructure agencies, members from academia and professional organizations, this process will serve as the roadmap for promoting greater integration and redundancy between critical infrastructure systems. As an integrated development planning initiative, this action brings a wide set of resilience dividends, namely: effective provision of critical services, reduction of exposure and fragility, reliability of mobility and communication, sustainable economy, and effective safeguards to human health and life.

Activities include:

- Define and characterize the Island's critical infrastructure using a criticality index for the assets, systems, and networks across sectors. Base the index criteria on socioeconomic factors, including prioritization of vulnerable and critical service dependent populations, a hierarchy of lifeline infrastructure, and prioritization of key assets for post-shock events.
- Assess critical infrastructure systems to highlight key interdependencies across energy, water, telecommunications, transportation, public facilities, flood protection, hospitals, among others.
- Identify evidence-based key actions, fostering opportunities for stronger and more resilient infrastructure.
- Develop an integrated knowledge-based platform to provide tools and strategies needed to implement infrastructure projects successfully. This platform can be developed through a public-private partnership (P3) and maintained by owners of critical infrastructure.
- Build capacity across infrastructure providers, decision makers, government officials, engineers, and the public.

Potential Lead
Puerto Rico Planning Board

Potential Co-leads
PROBM; PRSTRT; Universities; P3; Puerto Rico infrastructure public and private providers; regulatory boards and commissions.

Potential Funding Sources
CDBG-DR, Hazard Mitigation Grant Program, FCC, USDOT, DTPW

Unmet Needs

Crosscutting Benefits

Timeframe
Medium term

Description: General description of the action What is going to be done? how's gonna get done? With whom? Expected results

Timeframe: Short, Medium, Long term

Potential Lead: In charge of executing the action

Potential Co-leads: Partners that will support the development of the action

Potential Funding Sources: Federal, local, and philanthropic resources

Unmet Needs:

- Lack of integrated planning of the critical infrastructure
- Limited public participation in infrastructure planning
- Impaired asset management and operation of critical infrastructure
- Derelict and vulnerable utility and flood control infrastructure
- Lack of access to critical goods, services, and safety during post-disaster recovery
- Inadequate planning implementation and regulations enforcement
- Partial community planning capacity and lack of coordination
- Lack of risk assessments, and integrated emergency and contingency plans for critical infrastructure
- Limited fiscal and financial capacity to fund recovery actions
- Limitations for redundancy and next-generation networks, including complex permitting and construction regulations
- Lack of sustainable water resources
- Insufficient wastewater treatment

Crosscutting Benefits:

- Housing
- Energy
- Physical Infrastructure
- Education, health & Social services
- Economic Development
- Natural Infrastructure

Goal and Actions

Develop and maintain infrastructure systems that are accessible, integrated, flexible, and robust enough so they may sustain critical operations for the well-being of Puerto Ricans.

Critical Infrastructure Systems

A1 | Develop an integrated critical infrastructure management strategy to guide resilient long-term reconstruction.

A2 | Develop a master integrated Continuity of Operations Plan (COOP) for critical infrastructures and providers.

A3 | Implement an integrated flood risk management approach.

A4 | Develop a critical infrastructure assessment and priority recovery plan to prioritize recovery and ongoing operations of key transportation assets.

A5 | Improve the Puerto Rico Four Year Investment Program (PICA) with a risk-based asset management framework and integrated enforcement to embed resilience in the Island's infrastructure.

A6 Improve the Puerto Rico Dam Safety Program to ensure coordination between responsible agencies and enhance community preparedness.

A7 Assess and reduce the vulnerability of critical infrastructure against landslides.

A8 Develop and implement a Port Emergency Operations Plan.

A9 Improve the waste management industry to enhance metrics gathering, industry data mining and analysis, and fund allocation.

A10 Assess connectivity and develop a communication plan for primary anchor institutions.

Critical Infrastructure Sectors

A11 Commission a study of potential solutions to build an Island-wide Next Generation Network that supports the long-term telecommunication needs.

A12 Optimize recovery and reconstruction actions to the energy, transportation and telecommunications infrastructure to remove barriers to deployment and streamline building networks.

A13 Commission a study to support the development (underground and aerial) of a more resilient telecommunications infrastructure.

Goal and Actions

A14	Develop a sustainable mobility plan to enhance and integrate Puerto Rico's multi-modal transportation services and offer diverse and affordable transit access.
A15	Align reconstruction projects on the water systems to promote performance improvement on potable water infrastructure.
A16	Develop a water efficiency program to improve water demand management through water conservation and use of alternative water sources.
A17	Increase robustness and flexibility of vulnerable wastewater treatment systems.
A18	Protect existing drinking water sources and mitigate contamination in order to improve drinking water quality.
A19	Increase broadband adoption programs to support universal adoption of next-generation communications services.
A20	Develop a transportation technology strategy to integrate emerging technology services into the overall transportation network.
A21	Introduce alternative energy sources to power transportation-related infrastructure.

A22 Identify and integrate new drinking water sources into the water supply.

A23 Update Puerto Rico building codes in order to enhance their enforcement on critical infrastructure, and promote nature-based solutions.

A24 Establish redundant maritime sea cable connections.

A25 Develop an inventory of emergency response equipment, and train personnel to maintain and deploy such equipment.

Place-based Infrastructure

A26 Develop resilient community centers to improve the provision of services during emergencies and disaster relief.

A27 Develop a training and capacity-building program to promote local businesses and effective public participation throughout the recovery process.

A28 Develop an outreach and education program on domestic water treatment and storage in order to improve drinking water quality, at the point of consumption in times of emergency, for rural communities.

A29 Reconstruct decentralized wastewater systems to strengthen their recovery capacities.

A30 Improve solid waste management in urban and rural communities by adopting a circular economy approach.

A1 Develop an integrated critical infrastructure management strategy to guide resilient long-term reconstruction.

Description

A new vision for the reconstruction of Puerto Rico's infrastructure is critical for the Island's recovery. This recommendation envisions two main action areas: (1) an integrated infrastructure plan and (2) an infrastructure knowledge-based platform. Guided by the Puerto Rico Planning Board (PRPB), with active participation from Puerto Rico infrastructure agencies, members from academia, and professional organizations, this process will serve as the roadmap for promoting greater integration and redundancy between critical infrastructure systems. As an integrated development planning initiative, this action brings a wide set of resilience dividends, namely: effective provision of critical services, reduction of exposure and fragility, reliability of mobility and communication, sustainable economy, and effective safeguards to human health and life.

Activities include:

- Define and characterize the Island's critical infrastructure using a criticality index for the assets, systems, and networks across sectors. Base the index criteria on socioeconomic factors, including prioritization of vulnerable and critical service dependent populations, a hierarchy of lifeline infrastructure, and prioritization of key assets for post-shock events.
- Assess critical infrastructure systems to highlight key interdependencies across energy, water, telecommunications, transportation, public facilities, flood protection, hospitals,among others.
- Identify evidence-based key actions, fostering opportunities for stronger and more resilient infrastructure.
- Develop an integrated knowledge-based platform to provide tools and strategies needed to implement infrastructure projects successfully. This platform can be developed through a public-private partnership (P3) and maintained by owners of critical infrastructure.
- Build capacity across infrastructure providers, decision makers, government officials, engineers, and the public.

Potential Lead

Puerto Rico Planning Board

Potential Co-leads

OMB; PR Sciencie Trust; Universities; P3; Puerto Rico infrastructure public and private providers; regulatory boards and commissions

Potential Funding Sources

CDBG-DR; HMGP; FCC; USDOT; DTPW

Unmet Needs

Crosscutting Benefits

Timeframe

Medium term

A2 Develop a master integrated Continuity of Operations Plan (COOP) for critical infrastructures and providers.

Description

An integrated Continuity of Operations Plan (COOP) should be developed to ensure continued operation of the Island's critical facilities and infrastructures. This would ensure that all private and government agency services are effectively communicating and following a master emergency response plan. It will also help minimize disruptions of essential services across the Island, while supporting a quick recovery after an event. This thereby reduces likelihood of economic hardships and maintains the health and well-being of the population.

Activities include:

- Assess and examine current critical infrastructure conditions and cross-sector dependencies, to develop protocols for coordination among federal, local entities, and private service providers.
- Identify and operationalize protocols to improve cross-coordination between the government and the private sector during emergency response efforts. This is to ensure the continuity of essential services and the health and well-being of the population during a disaster.
- Design a COOP for immediate disaster coordination between agencies dealing with critical infrastructure and associated services, such as health, telecommunications, energy, transportation, and water. Align private business contingency plans, and integrate them into the Puerto Rico Disaster Risk Mitigation Plan, as well as the Puerto Rico Emergency Operation Plan.
- Integrate a comprehensive assessment and asset management system focused on improving the condition of assets, timely restoration of essential services, and the provision of reliable mobility.

Potential Lead

Government Authorized Representative

Potential Co-leads

PREMA; PRPB; FEMA; PREPA; PRASA; DTPW; PRPA; PRDHe; PRDE; telecommunication providers

Potential Funding Sources

HMGP; FCC; USDOT; DTPW; FEMA

Unmet Needs

Crosscutting Benefits

Timeframe

Short and medium term

A3 Implement an integrated flood risk management approach.

Description

An integrated flood risk management approach could create significant long term improvements across multiple systems.

Activities to support this action include:

- Redefine Puerto Rico's flood risk management vision and goals to influence scales and flood types, promoting principles *like living with water*[43], *water sensitive cities*[44] , *Room for the River*[45].
- Develop integrated policies and comprehensive emergency management plans to manage stormwater, river and coastal flooding, wastewater, and permit systems (such as the Puerto Rico Unified Information System).
- Review Flood Insurance Rate Maps and flood characterization tools to incorporate the impacts from María, as well as future impacts, including climate change.
- Improve forecasting technology and warning systems to maximize preparation time and the execution of emergency management plan actions.
- Create accessible risk awareness, permitting, and planning platforms based on FEMA's RiskMap program. This is to disseminate accessible and reliable flood mapping, as well as risk characterization information to all.
- Integrate and update planning platforms data related to flood insured properties databases (such as National Flood Insurance Program and other private products) using cadastre number and other acceptable georeferenced location.
- Implement bottom-up characterization of flood impacts (e.g., photos of the damage, mapping of flood extents, a measure of peak water elevations) and integrate impact characterization with emergency flood management plans and mitigation.
- Develop cost-benefit tools for direct benefits regarding reduced flood risk and improved socio-economic conditions.
- Establish a Flood Advisory Committee to:
    1. Address inefficiencies and limitations on Puerto Rico's flood management program.
    2. Share best technical and institutional practices.
    3. Advise agencies, insurance companies, and policymakers.
    4. Recommend funding structures for the sustainability of flood control infrastructures.
    5. Measure Island-wide progress and report it to the public.
    6. Promote innovation, community flood mitigation plans, and flood insurance programs.

Potential Lead

Puerto Rico Planning Board

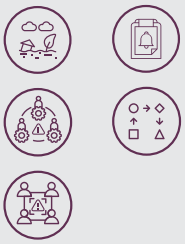
Potential Co-leads

GAR; PREMA; DNER; PRASA; FEMA; NOAA; Municipalities; federal and Puerto Rico government agencies

Potential Funding Sources

CDBG-DR; FEMA HMGP; NOAA; USDOT; DTPW

Unmet Needs



Crosscutting Benefits

Timeframe

Medium and long term

A4 Develop a critical infrastructure assessment and priority recovery plan to prioritize recovery and ongoing operations of key transportation assets.

Description

The development of a critical infrastructure assessment and priority recovery plan will allow key agencies to have a comprehensive view of the existing asset types and identify the criticality and level of importance in serving essential transportation functions. Also, this effort could gauge the level of impact caused by natural disasters and climate change.

The critical infrastructure assessment and priority recover plan should:

- Develop asset classifications across all transportation and physical infrastructures as to categorize representative assets and services.
- Assign a criticality index for infrastructure assets across all sectors and prioritize key assets for post-shock events. The index will identify network interdependencies needed to move people and goods across the Island (including delivery of supplies from ports and airports). It should also consider socioeconomic factors, including prioritization for vulnerable and transit-dependent populations and establishing a hierarchy for lifeline infrastructure.
- Develop priority scenarios to ensure efficient operations and effective disaster recovery efforts.
- Conduct a vulnerability assessment of the Island's key transportation assets, including identification of their exposure to shocks and stresses.
- Identify mitigation measures, such as programmatic strategies, preventive maintenance, ongoing asset management, and engineered improvements, in order to reduce impacts to key transportation assets.
- Incorporate the plan in broad decision-making processes regarding design requirements for new infrastructure and rehabilitation of existing infrastructure.
- Identify access, roads-based mobility, and type of vehicles used for hauling.
- Outline communication procedures and requirements to establish an inventory of baseline conditions and track road preventive maintenance measures. Establish an asset management framework.
- Build capacity across the Department of Transportation and Public Works (DTPW) and associated agencies to assume ongoing asset management responsibilities.

Potential Lead

Puerto Rico Department of Transportation and Public Works

Potential Co-leads

PRPB; UPR; PREMA; USDOT; FEMA

Potential Funding Sources

USDOT; DTPW; HMGP

Unmet Needs

Crosscutting Benefits

Timeframe

Medium term

A5

Improve the Puerto Rico Four Year Investment Program (PICA) with a risk-based asset management framework and integrated enforcement to embed resilience in the Island's infrastructure.

Description

The Puerto Rico Four-year Investment Program (PICA) should be improved to better coordinate and plan for growth and change in Puerto Rico. The PICA should foster coordination with the Financial Oversight and Management Board, an existing planning and budgeting processes, to identify and earmark critical infrastructure development and required maintenance of existing facilities. First, the PICA's framework needs to be re-evaluated to include a risk-based asset management approach that includes risk identification, an asset management framework and a multi-criteria cost-benefit analysis. Second, the reconstruction process should integrate critical infrastructure and cooperation between providers, such as the PRPB, PRASA, PREPA, DTPW, and telecommunication companies. This action will integrate post-disaster recovery efforts with existing institutional processes for the construction, operations, and maintenance of critical infrastructure in order to support directed growth and development.

The PICA is a capital improvement and investment program administered by the Puerto Rico Planning Board and is updated annually. It integrates the planned investments of the government and seeks to allocate and distribute the funds effectively to the highest priority areas. The integration of critical infrastructure projects in the PICA will help ensure the comprehensive and coordinated planning occurs on an ongoing basis.

Activities include:

- Define a life-cycle consideration (maintenance, capital investment, maximize value) and a risk-based framework that integrates multiple criteria and interests considering comprehensive assessments.
- Design a monitoring program to evaluate context-specific factors (including climate uncertainties) to value vulnerability and criticality of the assets, systems, and network.
- Regulatory boards and commissions should secure the level of investment for resilience measures.

Potential Lead

Puerto Rico Planning Board

Potential Co-leads

PREPA; PRASA; DTPW; PRPA; P3; PRDHe; Telecommunication companies; Regulatory boards and commissions

Potential Funding Sources

CDBG-DR; HMGP; USDOT; DTPW; FEMA

Unmet Needs

Crosscutting Benefits

Timeframe

Medium term

A6 Improve the Puerto Rico Dam Safety Program to ensure coordination between responsible agencies and enhance community preparedness.

Description

There is a need to improve the Puerto Rico Dam Safety Committee's responsibilities and actions to ensure coordination between responsible agencies and enhanced community preparedness. PREPA administers the Dam Safety Program in association with the Department of Natural and Environmental Resources (DNER), Puerto Rico Planning Board (PRPB), PRASA, and public-sector appointees by the Governor. However, the coordination and integration between these agencies is limited to periodical meetings with limited information sharing, where each agency responds directly to the Federal regulator. This action looks to facilitate long-term engagement among responsible agencies as they continue to manage dam infrastructures.

Activities include:

- Improve all plans and outreach related to dam safety.
- Integrate the Puerto Rico Emergency Management Agency in the Puerto Rico Dam Safety Committee.
- Review all the inundation maps for dams and reservoirs to ensure they are updated (including hazard characterization and GIS formats).
- Conduct flood risk characterization, map dam failure limits in Puerto Rico's comprehensives plan at the state and local level.
- Install early-warning systems, train local officials and community leaders, and conduct effective and participatory communities planning capacity.

Potential Lead

Governor's Authorized Representative

Potential Co-leads

PREPA; DNER; PRASA; PRPB; PREMA; FEMA

Potential Funding Sources

USACE; FEMA Dam Safety Program; HMGP

Unmet Needs

Crosscutting Benefits

Timeframe

Medium and long term

A7 Assess and reduce the vulnerability of critical infrastructure against landslides.

Description

This action focuses on developing an evidence-based landslide mitigation plan to design strategies that reduce current and future landslide impacts and meet the needs of communities, businesses, and institutions on the Island. These strategies can provide both short and long-term benefits to preserve transportation infrastructure and maintain operability of vital assets (telecommunications, energy and health services). The plan should include expanding landslide research, mapping, assessment, real-time monitoring, forecasting, information management and dissemination, mitigation tools, and emergency preparedness and response. Also, it should build upon existing federal resources, such as the National Landslide Hazards Mitigation Strategy.

Activities to develop the plan include:

- Convene relevant stakeholders, to be overseen by the Puerto Rico Department of Transportation and Public Works (DTPW), and identify programs and partner agencies to assist with the implementation of landslide mitigation strategies.
- Conduct a baseline condition assessment to evaluate areas impacted by landslides, the frequency of occurrences, and factors contributing to the affected areas. Geographical Information System (GIS) and natural resource modeling technologies will be used to map and assess landslide trends.
- Identify critical infrastructure and communities most vulnerable to landslides.
- Identify strategies to mitigate current and future landslide risks for different categories of slopes, geotechnical conditions, urban conditions, and other considerations that meet the needs of communities, businesses, and institutions on the Island.
- Develop education and outreach materials catered to relevant agency staff and affected communities.
- Identify pilot projects in high priority landslide areas to test opportunities to minimize future impacts from landslides and provide multiple community benefits, such as green infrastructure and beautification approaches to reduce soil erosion.
- Integrate the plan into mitigation and land use planning decisions made at the municipal and regional levels across Puerto Rico.

Potential Lead

Puerto Rico Department of Transportation and Public Works

Potential Co-leads

USGS; Universities; PRPB; DNER; FEMA; PREMA

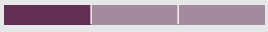
Potential Funding Sources

USDOT; DTPW; HMGP

Unmet Needs

Crosscutting Benefits

Timeframe



Short term

A8 Develop and implement a Port Emergency Operations Plan.

Description

Puerto Rico's ports should establish and follow an Emergency Operations Plan designed to coordinate local and regional distribution of goods after a disaster. During emergencies or stressed conditions, the ports are the epicenter of logistics and enabler of goods to be brought to the Island. Puerto Rican businesses and communities strongly rely on goods movement through its ports. Also, under normal conditions, the Island's economic prosperity hinges on the ability of goods to be transported efficiently and cost-effectively. Therefore, ensuring that ports facilities suffer minimal damage and reopen more quickly after an event will secure the health and well-being of islanders and will minimize disruption to daily life (e.g., supply of essential goods).

The development of a Port Emergency Operations Plan should include both port-specific and coordinated efforts between ports. Initiated by the Ports Authority (PRPA), this plan should strategically allocate goods and ensure continuous information exchange during extreme natural events and disasters. The plan will aid the assesment of the latest conditions and determine the capacity and operability of ports in order to maintain movement of goods for immediate disaster relief. It would also implement resilient design and operational practices that enable rapid recovery post-disaster. The working group recommends the following high-level tasks to initiate the development of this plan:

- Establish emergency management goals and performance standards on ports facilities to determine a minimum threshold for operability standards required during and post-disasters.
- Develop a concept of operations for maintaining operability across ports during and post-disasters.
- Develop a mitigation monitoring program and structure for information-sharing to track progress and minimize future disruptions.
- Conduct key stakeholder meetings and relevant staff training to disseminate protocols established through the plan.
- Review the tax on inventory during hurricane season and the impact on the availability of goods within Puerto Rico.

Potential Lead

Puerto Rico Ports Authority

Potential Co-leads

DTPW; Port Associations and private companies; Transport unions and associations; Association of Marketing; Industry and Food Distribution; PRTD; PREMA; DHS; FEMA

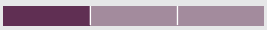
Potential Funding Sources

USDOT; DTPW

Unmet Needs

Crosscutting Benefits

Timeframe



Short term

A9 Improve the waste management industry to enhance metrics gathering, industry data mining and analysis, and fund allocation.

Description

There is a need to improve metrics gathering, industry data mining and analysis, and fund allocation to professionalize and integrate the waste management industry. This action aims at strengthening the ISWM goals[46]. The goals and premises established by these legislative documents are considered sufficient, but have since lacked enforcement.

Initial tasks could include:

- Reinforce education stemming from all waste management industry-related stakeholders through certifications and compliance programs.
- Implement proactive professional education or development initiatives, integrating local resources brought together by professional organizations and universities.
- Integrate soft skills into the program for metrics gathering and analysis improvement, which is considered the baseline for ISWM strategy development.

Potential Lead

Puerto Rico Solid Waste Authority

Potential Co-leads

Waste Management Industries; DEDC; EQB; PR Science Trust; Municipalities; Federal and Puerto Rico government agencies

Potential Funding Sources

EPA; FEMA-Public Assistance; CDBG-DR; USDA; P3; Municipalities funds are available for professional development

Unmet Needs

Crosscutting Benefits

Timeframe

Medium and long term

A10 Assess connectivity and develop a communication plan for primary anchor institutions.

Description

The action seeks to develop a Communications Network Plan for anchor institutions at the municipal level in order to identify key facilities and develop strategies and protocols to enhance communication during and after disaster events. The prioritization of digital infrastructure at these locations is also important, as they store relevant data crucial for governmental coordination and serve as community resources for critical services pre-and post-disaster events.

Anchor institutions, such as schools, hospitals, and shelters, serve as key locations for the provision of community resources, especially in disaster relief situations. Coordination across these anchor institutions is crucial to ensure recovery and promote communities' well-being. Residents and business owners use these facilities every day, are familiar with them and can seek communications and digital infrastructure support during system failures across other building uses, including their homes. In addition, they can serve as emergency relief centers for food, water, clothing and other critical supplies.

A crucial step is to review the list of anchor institutions, verify information such as type, location, and contact details, and assess the current type of Internet access, vendor, and level of service.

Potential Lead

Puerto Rico Emergency Management Agency

Potential Co-leads

FCC; Telecommunication private companies; Federal and local government; schools; hospitals; shelter service providers

Potential Funding Sources

HMGP; CDBG-DR

Unmet Needs

Crosscutting Benefits

Timeframe

Short term

A11 Commission a study of potential solutions to build an Island-wide Next Generation Network that supports the long-term telecommunication needs.

Description

The recovery efforts on the telecommunication infrastructure should be based on a high-level study to define solutions to build the Island-wide next-generation network. This study should include Connect Puerto Rico's work portfolio and a framework designed to support stakeholder's current conditions and decision-making process. The existing wireline network infrastructure will upgrade from copper-based to fiber-based network and the current wireless infrastructure from 4G to 5G.

The priorities of this study will include:

1. Fast, robust, redundant and ubiquitous broadband access to meet the economic challenges of the 21st Century.
2. A middle-mile fiber-optic network.
3. Increased densification of wireless assets in support of 5G.
4. Anchor institutions connections, including schools, hospitals, research facilities, manufacture, and government facilities with fiber-optic infrastructure.

This would maintain urban and rural access to communication during and after occurring natural events. Action steps include:

- Coordinate with regional and municipal agencies and private infrastructure providers.
- Base assessment on the developed Island-wide detailed map of broadband coverage to accurately pinpoint remaining gaps in broadband availability.
- Review 5G franchise agreements, pole, conduit, and tower attachment regulations and agreements, and a streamlined make-ready process to speed up deployment.
- Identify short, mid, and long-term fiber optic improvements, as well as areas that could serve as connected communities.
- Collect data from all pole locations, residential and business locations, anchor institutions and other important telecommunications infrastructure, including hub sites, towers, and fiber cables.
- Develop an Island-wide franchise agreement for small-cell deployment locations between the pole-owner and potential vendors.
- Analyze and streamline the pole survey, pole attachment and make-ready processes for aerial fiber-optic cable deployment.

Potential Lead

Puerto Rico Central Office for Recovery, Reconstruction, and Resilience

Potential Co-leads

TRB; OCIO; PRIFA; FCC and PREPA

Potential Funding Sources

FCC; USAC; USDA; USDOT and DHS

Unmet Needs

Crosscutting Benefits

Timeframe

Medium term

A12 Optimize recovery and reconstruction actions to the energy, transportation and telecommunications infrastructure to remove barriers to deployment and streamline building networks.

Description

This action looks to optimize actions of the recovery and reconstruction process in order to reduce barriers to deployment and streamline telecommunication building networks. Reconstruction activities related to energy, transportation, telecommunications and other critical utilities should be coordinated to take advantage of the efforts and deploy the next generation telecommunications infrastructure. Currently, underground conduits are very limited in Puerto Rico and are only found in limited deployments.

These optimized actions can be implemented based on the Dig Once policy and following regulations for federal-funded transportation projects. The Dig Once policy mandates the inclusion of broadband conduit (plastic pipes which house fiber-optic communications cable) during the construction of roads receiving federal funding. As a result, the Dig Once policy could expand broadband at a fraction of the cost by including the conduit as roads are being built.

Action steps include:

1. Commission a study as a first step before making investments into new telecommunications capital projects. Study deliverables should build on existing work and include specific changes, steps to achieve those changes and identify parties required to achieve changes.
2. Review existing regulations and processes to remove barriers to deployment.
3. Review feasibility to implement Dig Once policies on new roads, mass-transit projects, sidewalks, housing developments, and other construction projects, partially or fully funded by the Government of Puerto Rico and the private sector.
4. Include the incorporation of conduits that can house fiber-optic cable that will sustain future data services (high-speed broadband/IPTV/Voice Over IP, etc.) on reconstruction initiatives plans.
5. Define legislation in the long-term to incorporate the Dig Once approach, which should be competitively neutral by ensuring that all broadband providers, regardless of the technology used or regulatory status, have equal access to these conduits.

Potential Lead

Puerto Rico Central Office for Recovery, Reconstruction, and Resilience

Potential Co-leads

DTPW; TRB; PREPA; PRASA; FCC

Potential Funding Sources

HMGP; FHWA; CDBG-DR and Telecommunication providers

Unmet Needs

Crosscutting Benefits

Timeframe

Short and medium term

A13

Commission a study to support the deployment (underground and aerial) of a more resilient telecommunications infrastructure.

Description

Before making capital investments into new infrastructure, a study should be commissioned to assess the best way to harden and protect the telecommunications and the energy transmission infrastructure. This study should include feasibility and cost-benefit of establishing an underground utility conduit system versus hardening the aerial Infrastructure. The Puerto Rico telecommunications network sustained complete failure as a result of the hurricane. This was due to winds, wind-powered debris, falling tree limbs, and landslides.

Protecting the utility plants will make the network more resilient and mitigate shocks and stresses to the system. It is unlikely that any system can completely prevent outages, but a study would show which investments will have the best value. Deploying utilities in the underground conduit is generally more expensive than deploying on poles. Poles should be upgraded, and better attachment and maintenance procedures like tree trimming could mitigate against damage at a reduced cost.

The risk of future shocks and stresses impacting the utility plant is high. Therefore, the primary solution would be to move utility plants off aerial utility poles and into underground conduit. This solution must focus on building a redundant middle mile ring around the Island, along major highways.

Regarding implementation, direct burial conduit is a proven deployment practice, and the cost of deploying conduit, especially in conjunction with road work, can be cost-effective. Deploying a shared underground conduit bank for telecommunications and power cables, in a ring around the island, could help lay the foundation for this underground network in the near-term. In the long-term, it would potentially continue for utility infrastructure expansion.

Potential Lead

Puerto Rico Electric Power Authority

Potential Co-leads

TRB; Electrical Conduit Suppliers for Puerto Rico (e.g., American Wire Group, Underground Devices, Inc., Gibson Stainless & Specialty, Inc.); FCC

Potential Funding Sources

5G - franchise fee revenue; FCC - Universal Service Fund

Unmet Needs

Crosscutting Benefits

Timeframe

Short and medium term

A14 Develop a sustainable mobility plan to enhance and integrate Puerto Rico's multi-modal transportation services and offer diverse and affordable transit access.

Description

A sustainable mobility plan should be developed, defining a roadmap to sustain and enhance economic productivity and citizens' health and wellbeing, as well as to plan for current and future negative externalities on the transportation network. The plan will foster vibrant urban areas and well connected rural communities, greenhouse gas reductions, connectivity of activity and job centers, and leverage new transportation services to better serve vulnerable populations in post-disaster scenarios. Transport systems should be created in response to land uses by planning compact, dense, and mixed land uses in conjunction with transportation and increased access to efficient and affordable transport. The plan should promote new technologies and mobility options to create a truly integrated and multimodal mobility system for Puerto Rico while building on the 2013 Long Range Transportation Plan (LRTP).

The ability of citizens to easily travel to their jobs, schools, places of worship, medical care, and leisure activities is the backbone of a thriving economy and society. Transportation systems relying heavily on single occupancy vehicles (SOVs), rather than an integrated, multi-modal system can have negative externalities and hinder post-disaster recovery. Also, transportation could exacerbate economic challenges, for example, in average Puerto Rican families spend nearly 30% of their budget on expenses related to transportation.

Action steps include:

1. Conduct a comprehensive assessment of current travel demand, travel behavior, land uses, and future travel demand to forecast future mobility needs.
2. Evaluate emerging transportation services, including shared mobility offerings, public and private provision of on-demand transportation (i.e., bike share and car share), transportation network companies (TNCs), and micro transit.
3. Identify opportunities to enhance the existing network of roadways, public transit, and active transport (cycling and walking).
4. Identify relevant travel demand management strategies that encourage sustainable transportation behaviors, such as remote working or Transit-Oriented Development (TOD).
5. Define pilot projects to increase public transit services, shared mobility services, and other travel demand management programs. These would measure community interest and the effectiveness of improving access and reducing reliance on SOVs.

Potential Lead

Puerto Rico Integrated Transit Authority

Potential Co-leads

DTPW; RTA

Potential Funding Sources

USDOT

Unmet Needs

Crosscutting Benefits

Timeframe

Short and medium term

A15 Align reconstruction projects on the water systems to promote performance improvement on potable water infrastructure.

Description

This action is focused on enhancing reconstruction projects on the Puerto Rico Aqueduct and Sewer Authority (PRASA) with a long-term vision of a water utility that addresses society's needs, while being physically, economically and environmentally sustainable. Reconstruction projects should systematically improve PRASA services by working on cost-effective, reliable and sustainable performance improvements in all operational facets. To create an impact with these opportunities, an aggressive system-wide approach should be focused on (1) identifying communities with the greatest need to prioritize system upgrades and expansion, while securing long-term programs funding, and (2) incorporating information and technology developments to improve PRASA's operation and ensure a viable utility long into the future.

PRASA faced significant challenges to provide sustainable services to its customers and extend service provision into underserved (rural) communities, while it is confronted with a fiscal crisis, aging infrastructure, stringent regulatory requirements, service demand changes, a changing workforce and depleting water resources. Addressing these challenges requires rethinking the reconstruction projects and collaboration between PRASA, government, industry, communities and other stakeholders.

Action steps include:

1. Conduct a comprehensive performance assessment and compare among utilities with similar challenges to review the existing performance improvement plan and key performance indicators.
2. Prioritize projects to produce potable water, treated effluent, and process residuals in full compliance with regulatory and reliability requirements and consistent with customer, public health, and ecological needs.
3. Incorporate community/customer participation and engage employees

Potential Lead

Puerto Rico Aqueduct and Sewer Authority

Potential Co-leads

DNER; EQB; EPA; FEMA

Potential Funding Sources

USDA; HMGP

Unmet Needs

Crosscutting Benefits

Timeframe

Medium term

in improvement efforts that seek and celebrate step-by-step victories and considerably reduce operation cost.

4. Implement a comprehensive customer identification survey (existing and potential) and update and develop a GIS-based customer database.
5. Assess current IT solutions and suitability of hard- and software and build an integrated system of solutions that allows for effective financial and commercial management (e.g. accounting, billing).
6. Conduct an energy audit and develop an energy efficiency program to reduce operational costs and improve emergency operations.
7. Improve water management and automate water meter reading including monitoring of water levels, withdrawal, balance, flow rates, water quality and pollution, sending automated water meter readings to allow actual consumption to be billed in real time, controlling water flow to customers and import data into billing systems, using improved water data to track surface and groundwater availability, monitoring pipeline integrity and detecting water leaks.
8. Implement a comprehensive leak detection and repair program based on automated meter reading technologies, replacing large water meters on industries, and monitoring system pressure zones.
9. Improve asset management with a risk assessment framework, performance with monitoring system, and the decision-making framework with an integrated water cycle management.
10. Conduct tariff review and propose amendments.
11. Prepare a comprehensive contingency and emergency plan and standard operating procedures to ensure the provision of safe services and taking into account the experiences from hurricane María.

A16 Develop a water efficiency program to improve water demand management through water conservation and use of alternative water sources.

Description

Education and technical assistance programs should be designed and implemented to inform the public about the impact of water efficiency and conservation, to promote behavior change in the long run. The program will incentivize customers to notify PRASA of leaks and damaged infrastructure to reduce losses in the distribution network and to notify the Puerto Rico Department of Natural and Environmental Resources (DNER) and the Environmental Quality Board (EQB) of any water contamination problems in their communities. Also, guidance, and incentives will be developed for the use of rainwater and greywater harvesting and other non-potable water sources. Water conservation is a critical element of enhancing the resilience of water systems and is proven to be the most economical and environmentally protective management tool for meeting water supply challenges. Water conservation and the enhanced use of alternative sources largely depend on public awareness and understanding, and incentives created.

Action steps include:

1. Develop water balances for all community water supply schemes, Standard Operation Procedures (SOPs) to enhance performance and reduce losses, and action plans for water loss control.
2. Develop a water conservation program including an outline of conservation goals and objectives to use alternative sources, including reuse and reclaimed water opportunities, and demand forecast reflecting savings from efficiency program. Establish measurable conservation goals with all water service providers on the island, which include public consultation and annual progress reports. Improve data collection and reporting on water consumption/use (annual and "seasonal variations" consumption) by customer class for all water systems and service providers on the Island.

Potential Lead

Puerto Rico Aqueduct and Sewer Authority

Potential Co-leads

PREPA; DNER; EQB; EPA; FEMA; NGOs

Potential Funding Sources

HMGP; EPA; USDA; CDBG-DR and PRDE

Unmet Needs

Crosscutting Benefits

Timeframe

Medium and long term

3. Develop public outreach training activities with relevant stakeholders aiming at conveying water conservation, schools' educational programs, industrial water consumption and bill format that provides customers with water efficiency measures.
4. Promote the EPA - WaterSense Program to protect water resources by promoting water efficiency and enhancing the market for water-efficient products, programs, and practices.
5. Develop necessary regulation, permitting and guidelines procedures for alternative water systems (rainwater or greywater systems) to prevent possible contamination of the public water supply system.
6. Review existing building codes to mandate low use plumbing fixtures and develop a municipal water efficiency program to make public buildings more efficient by e.g., retrofitting plumbing fixtures.
7. Develop and implement a training program for (community) water supply operators on how to operate the systems more efficiently and to minimize water loses within the distribution and treatment systems.

Caguas, PR. C3Tec

A17 Increase robustness and flexibility of vulnerable wastewater treatment systems.

Description

A strategy to increase robustness and flexibility of the wastewater infrastructure is essential to ensure public and ecosystem health and safety, ensuring reliable and sustainable services to the people of Puerto Rico. Modifications, including elevating electrical components, relocating facilities, increasing redundancy, providing suitable backup power systems and establishing robust contingency and emergency plans, can increase its resilience capacity. Thereby, the intervention should consider exposure, sensitivity and adaptive capacity by (a) examining the threats (such as flooding and hurricanes), (b) determining impacts to utility assets, and (c) identifying cost-effective mitigation options.

Action steps:

1. Understand threats based on existing and new information, such as flood modeling and risk map.
2. Estimate system vulnerability based on consequences, key utility assets/ operations replacement costs, impacts to operations and reviews of assets condition and prevailing operational risks.
3. Identify, evaluate and prioritize mitigation actions during hazard events based on vulnerabilities, consequences of failure and degree of exposure, critical assets, and operations, and cost, effectiveness, and practicality (e.g., emergency procedure, elevating equipment or backup generators).
4. Develop a plan to implement the mitigation measures that includes schedule, funding, and responsibilities.
5. Integrate mitigation measures that involve major capital and infrastructure investments in the asset management planning, investment planning and budgeting schedule to refurbish or relocate assets.
6. Explore funding sources for mitigation measures including internal utility capital improvement funding, local/state funding/bonds.

Potential Lead

Puerto Rico Aqueducts and Sewers Authority

Potential Co-leads

FEMA; EPA; EQB; PREMA; PRPB

Potential Funding Sources

HMGP; USDA; EPA's tool Federal Funding for Utilities in National Disasters (Fed FUNDS) and CDBG-DR

Unmet Needs

Crosscutting Benefits

Timeframe

Medium term

7. Review contingency and emergency operation/response plans based on mitigation measures and procedures to maintain operations and effectively dispose of wastewater.
8. Perform an energy audit of sewerage systems to identify energy saving opportunities by modifying operations and equipment, integrating energy efficiency and backup power program and using alternative energy systems. Alternative systems will potentially supplement backup power supply, ensure continuous electricity, reduce overall electricity cost and remove dependence on the electrical grid (e.g., cogeneration units and a waste heat recovery system at wastewater treatment plants).
9. Establish a pilot monitoring system for the sewer network which will allow the identification of blockages or other disruptions and will clear them before problems occur.

Wastewater, PR. USDA

A18 Protect existing drinking water sources and mitigate contamination in order to improve drinking water quality.

Description

This action focuses on preventing and mitigating contamination of raw water sources (such as reservoirs/dams, streams, rivers, and aquifers) to maintain and improve potable drinking water and promote environmental and public health. Source water can be vulnerable to accidental or intentional contaminants and weather-related changes.

Action steps include:

1. Improve monitoring of source water quality and to design specific protection and mitigation measures to improve water quality consecutively. Service providers should be able to anticipate changes to the treatment process based on storms, algal blooms, industrial discharge, chemical spills, reservoir stratification/destratification, construction activity, sewage spills and other occurrences.
2. Develop an integrated platform and maps that include an inventory and classification of raw water sources, water quality monitoring parameters based on the water source, regulatory and operational requirements, source protection areas, and classified pollution sources and contamination risks for critical water sources including septic tanks, agricultural sources, and effluent discharge points.
3. Review and improve water monitoring roles and responsibilities, processes and standard operating procedures and monitoring devices/ infrastructure based on best practices and industry standards.
4. Develop innovative practices and strategies for land use decisions and establish new land zoning to reduce the vulnerability of aquifers and surface waters to contamination from developments, industrial, agricultural and other sources, including protection of drinking water source and aquifer recharge areas.
5. Establish source water collaborative to define common goals and challenges, ensure ongoing coordination of effort and initiatives by allowing relevant stakeholders including the public and the private sector to meet regularly and work together on mutual priorities.

Potential Lead

Puerto Rico Department of Natural and Environmental Resources

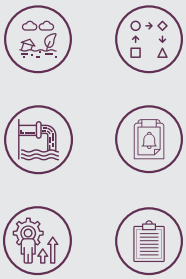
Potential Co-leads

PRASA; EPA; PRDHe; EQB; PRPB; FEMA

Potential Funding Sources

USDA; EPA; FEMA

Unmet Needs



Crosscutting Benefits

Timeframe

Medium term

6. Develop a communications and outreach plan to build support for source protection activities and good agricultural practices among relevant stakeholders.
7. Review investment plans to protect drinking water sources, establish the economic value of protecting drinking water sources and develop innovative funding mechanisms for local incentive initiatives.
8. Work with industrial, governmental, and other large water consumers to mitigate contamination, establish sustainable groundwater withdrawal rates, and minimize waste.
9. Assess the risk of saltwater intrusion of aquifers and subsidence, and improve groundwater extraction authorization, regulation, and permitting.
10. Develop innovative pilot projects for adequately designed septic tanks, and recharge vulnerable aquifers.

Utuado, PR. Joshua DeMotts

A19 Increase broadband adoption programs to support universal adoption of next-generation communications services.

Description

The Puerto Rico Broadband Strategic Plan details the challenges and potential solutions to broadband adoption on Puerto Rico. Advancing these solutions for access and adoption programs in Puerto Rico will have multiple benefits from increased subscriber rates and revenues to helping drive investment, improving service delivery to some of those most in need of assistance and closing the digital divide. Telecommunications vendors have concerns about making expensive network upgrades and expansions while the Puerto Rico population is fluctuating and the number and location of subscribers are unknown.

Additionally, some of the Islands most vulnerable population segments have not adopted advanced telecommunications services due to several factors including cost. Non-adopters are unable to be part of the digital transformation and often suffer from isolation. There are many successful examples of technology adoption programs that can help specific demographics develop essential digital skills and increase access and meaningful use of advanced services.

Potential Lead

Puerto Rico Telecommunications Regulatory Board

Potential Co-leads

Libraries; Schools; Vendors and NGOs

Potential Funding Sources

NTIA and vendors

Unmet Needs

Crosscutting Benefits

Timeframe

Short and medium term

Arecibo, PR. Norma Arbelo Irizarry

A20 Develop a transportation technology strategy to integrate emerging technology services into the overall transportation network.

Description

As Puerto Rico moves beyond disaster response, a transportation technology strategy should be developed to ensure long-term resilient, robust, and high-quality transportation services. The strategy will provide a forward-looking approach to incorporate new transportation services into the overall network and technology across public and private transportation services. A platform for transportation innovation will be established while ensuring that the Island can meet its safety, environmental, mobility, and equity goals and objectives. The strategy will leverage the long-term planning established through Puerto Rico's Metropolitan Planning Organization (MPO), the Islandwide Long-Range Transportation Plan (LRTP), and the State Transportation Improvement Program (TIP).

There will be a focus in three areas that are experiencing dramatic change due to the onset of new technologies and the need to adapt to future necessities and opportunities: data, mobility, and infrastructure. The focus on data looks to ensure real-time data and quick exchange of real-time conditions across public and private transport operators. The mobility area focuses on planning for multi-modal transportation options and ensuring connectivity in the physical landscape, through a convenient information platform for customers, real-time information and streamlined fare payment. In turn, the focus on infrastructure looks towards optimizing integration of technology into the construction, operations, and maintenance of key transportation assets. It also looks to optimize potential revenue-generating opportunities from infrastructure user fees to ensure the sustainability of investments.

Potential Lead

Puerto Rico Department of Transportation and Public Works

Potential Co-leads

COR3; PR Science Trust; Universities; RTA

Potential Funding Sources

USDOT

Unmet Needs

Crosscutting Benefits

Timeframe

Medium term

Actions steps include:

1. Project kick-off/scoping workshop: convene key public and private transportation stakeholders in Puerto Rico to establish goals, objectives and working cadence of the project.
2. Industry best practices review: review current industry trends around emerging transportation technologies, with a focus on data, mobility, and infrastructure.
3. Stakeholder interviews: conduct outreach with relevant stakeholders to assess opportunities and challenges from product and technology providers, transportation providers, and policy-makers.
4. Framework for pilot and program opportunities: leveraging available data, policies, and plans, refine priority technology opportunities and forthcoming policy and program decisions. Define recommendations for pilot program opportunities and develop a long-term system architecture for integrating data, mobility and infrastructure technology throughout key transportation partners.

California, US. VGrigas (WMF)

A21 Introduce alternative energy sources to power transportation-related infrastructure.

Description

As transportation is a heavily power-dependent sector, and disasters typically impact traditional energy sources, this action suggests assessing opportunities to generate alternative energy and introduce independent energy sources and add redundancy to the system, to ensure higher reliability and resiliency. This assessment should include an evaluation of diverse distributed energy sources, including the use of solar power, batteries, and kinetic energy as a means of generating electricity.

Also, this action includes the development and implementation of a pilot program to expand the use of distributed energy sources to provide power supplies to transportation-related assets and facilities. The aim is to reduce dependency on the electrical grid and provide alternative, independent and redundant energy sources. This action responds to both immediate issues resulting from shocks like Hurricanes Irma and María, while also providing more resilient solutions utilizing alternative energy technologies to provide redundant power sources for critical transportation infrastructure. The opportunities assessment and subsequent pilot program will evaluate the transportation infrastructure that could be optimized through alternative energy sources, such as roadway lighting and traffic signals.

Traffic signals failure, for example, can significantly impact disaster recovery by increasing traffic congestion. Traffic chaos delays access to services and require the support of additional workforce to maintain traffic flows in more congested intersections.

Action steps include:

1. Identify priority transportation infrastructure whose outages, following Hurricanes Irma and María, significantly impacted recovery efforts due to ensuing traffic chaos and subsequent travel delays.
2. Identify potential alternative power sources to supply the prioritized circuits of traffic lights in the instance of a grid outage.
3. Carry out a technical feasibility study of alternative power sources, including a cost-benefit analysis of each alternative relative to its ability to support critical traffic signal functionality for post-disaster recovery.
4. Identify pilot project and funding to install alternative power sources.

Potential Lead

Puerto Rico Department of Transportation and Public Works

Potential Co-leads

COR3; FEMA

Potential Funding Sources

USDOT; CDBG-DR

Unmet Needs

Crosscutting Benefits

Timeframe

Short and medium term

HeyouRelax

A22 Identify and integrate new drinking water sources into the water supply.

Description

Integrated strategies should be developed to diversify water resources and build additional redundancy into the water reservoir system. Water is a key driver of economic and social development while it also has a basic function in maintaining the integrity of the natural environment. However, water is only one of several vital natural resources, and it is imperative that water issues not be considered in isolation.

Therefore, the traditional fragmented approach is no longer viable, and the island urgently needs to adopt a holistic approach to water management which aims to create sustainable water security within the present constraints and to improve conditions in the catchment basins. Based on a comprehensive water resources assessment and reliable water demand projections for long-term infrastructure investments, suitable options need to be prioritized and funding secured to ensure sustainable development, management, and protection of water resources, society and ecosystem.

Action steps include:

1. Develop a clear vision on water resources and a flexible water allocation plan that reflects sector plans and offers the most effective and efficient utilization of a basin's resource, learning from the aftermath of Hurricane María and drought events.
2. Review existing laws, plans and regulations to determine how to accommodate sustainability and integrate water resources management.
3. Review and harmonize existing plans for sustainable management and development of water resources to ensure reliable water supply and meet future water demands based on realistic projections.
4. Perform a comprehensive assessment and inventory of the status of existing water resources, the budget for cost-effective options taking into consideration maintenance and protection, and promote cost recovery including government grants, user charges, taxes, donor funds, among others.

Potential Lead

Puerto Rico Water and Sewer Authority

Potential Co-leads

DNER; FEMA; PRPB; USGS

Potential Funding Sources

PRASA; DNER; FEMA

Unmet Needs

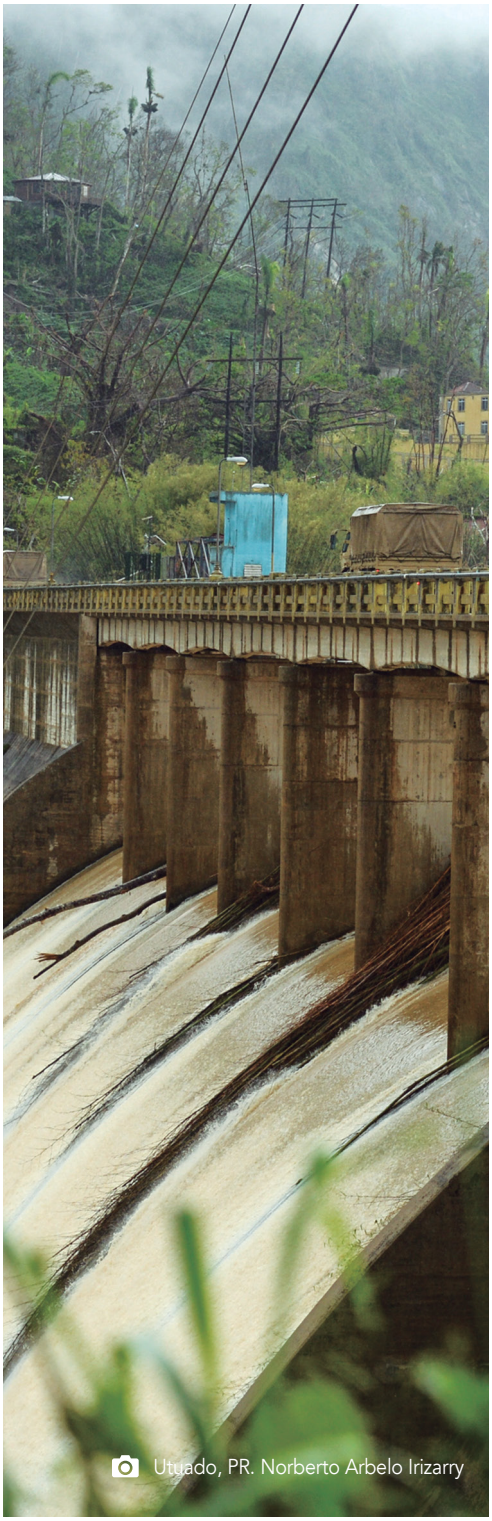
Crosscutting Benefits

Timeframe

Medium term

A22

5. Facilitate political will and commitment at all levels to make necessary changes in the legal and institutional structures, gain sectoral support and ease the public pressure.
6. Develop a participation and coordination mechanism, foster information sharing and exchange, and maintain and accrue sound knowledge and information.
7. Develop capacities and training priorities at local government, communities and the private sector.
8. Identify and implement pilot measures to protect existing water resources.
9. Establish a comprehensive monitoring system to manage water resources properly and to identify needs for adjusting management strategies and evaluate new technologies for effective performance.



Utuado, PR. Norberto Arbelo Irizarry

A23 Update Puerto Rico building codes in order to enhance their enforcement on critical infrastructure, and promote nature-based solutions.

Description

Policy recommendations are focused on improving the implementation of the Puerto Rico Building Code by integrating actions that will re-evaluate needs on critical infrastructure, define requirements for adequate maintenance, promote integrating systems and improve the reviewing process by incorporating risk assessment and criticality. The codes should also promote nature-based solutions. The review process should be performed with industry leaders so that they may provide valuable input, not only regarding construction but also within other areas of regulation, including the preservation of natural resources and coastal development.

The 2011 Puerto Rico Building Code (PRBC) provides minimum requirements to safeguard public health, safety, and the general welfare of the occupants of new and existing buildings and structures. Currently, the Permit Management Office (PMO) is reviewing construction standards and codes that will impact design and development for years to come. There is an expressed need for greater participation and coordination between industry experts and the government agencies that oversee the development of these standards. Additionally, there is a need to improve public participation and directed industry leadership in order to ensure better development of codes and that sustainability and resilience standards are in place.

Potential Lead

Permits Management Office

Potential Co-leads

PRPB; GAR; FEMA; Puerto Rico Professional Colleges; industry leaders

Potential Funding Sources

HMGP; USDOT; FCC

Unmet Needs

Crosscutting Benefits

Timeframe

Medium term

A24 Establish redundant maritime sea cable connections.

Description

Cable owners and operators should be encouraged to examine the feasibility of moving or adding new cables to increase redundancy of the sea cable connections. There are currently 19 maritime telecommunications cables that connect Puerto Rico to the mainland United States, South America, and other Caribbean islands.

All maritime cables entering Puerto Rico terminate near the San Juan metropolitan area along the North coast. Their placement in a single geographic area creates a risk and a significant shock to the area could damage some or all the cables and create a complete system failure that could take a long time to repair. Some cables pass close to Ponce and other locations on the South and West of the Island. If these existing cables or new cables were to enter Puerto Rico through additional areas, it could help create redundancy, mitigate risk, and establish a more resilient network.

Potential Lead

Puerto Rico Telecommunications Regulatory Board

Potential Co-leads

Maritime cable owners and operators

Potential Funding Sources

Maritime cable owners and operators

Unmet Needs

Crosscutting Benefits

Timeframe

Medium term

A25 Develop an inventory of emergency response equipment, and train personnel to maintain and deploy such equipment.

Description

This action focuses on ensuring communities receive appropriate resources and services by deploying emergency equipment (i.e., temporary bridges, mobile clinics, and shelters) by staff trained in deploying emergency relief services. Natural disasters regularly damage key physical infrastructure that often serve as the only point of access to an area. This disrupts access and the ability to provide disaster relief and enable rapid recovery.

This action would include an assessment and the purchase and provision of temporary equipment and infrastructure to support access to goods and services to enable post-disaster recovery. Also, training and assembly of emergency equipment should be coordinated Islandwide, specifically with DTOP, the Fire Department, and the Health Department, for ongoing operations and maintenance. In conjunction with a critical infrastructure assessment, an assessment of key temporary infrastructure will provide a detailed picture of the transportation network and other physical infrastructure that is at risk during times of disaster. This will help to better prepare anyone needing access to the network. It will also help ensure less disruptions, thereby reducing the likelihood of economic hardships and maintaining health and well-being.Furthermore, ensuring a local inventory of materials for deploying temporary emergency equipment is critical to reduce wait times for the shipment of goods to the Island. Consequently, in the event of a natural disaster, materials and goods can be readily deployed.

Recommended next steps for this action include the following:

- Research deployable emergency equipment that would be suitable to temporarily replace the prioritized infrastructure.
- Carry out cost-benefit analyses to identify the value of deploying temporary infrastructure and identify priority equipment to enable rapid response and recovery. Train personnel in the operations, storage, and maintenance of the emergency equipment and temporary infrastructure, including, repurposing of materials after their useful life.

Potential Lead

Puerto Rico Emergency Management Agency

Potential Co-leads

Puerto Rico National Guard; DTPW; PRDHe; PRDF; USDOT; FEMA

Potential Funding Sources

HMGP; USDOT; P3

Unmet Needs

Crosscutting Benefits

Timeframe

Short and medium term

A26 Develop resilient community centers to improve the provision of services during emergencies and disaster relief.

Description

Key locations that provide services to communities in various municipalities across the island could be adapted into resilient community centers. The key is to identify physical spaces that serve communities with social, economic, health and education services that could be transformed into these Resilient community centers. These Resilient Community Centers would provide multiple cross-sector benefits to the community, such as pre-k, educational classes, and workforce training programs while offering a space for disaster relief services and ongoing provision of resources to the community.

During emergency response situations, the Resilient Community Centers would serve as command hubs for communication with Federal and local agencies and offer digital communication services for communities and businesses with limited to no access. Additional services could include access to a digital lifeline, such as radio communication and a command center, provision of water, information, and medical services. Also, the Resilient Community Centers should have redundant energy and water services, focused on renewable energy, rain harvesting, and community gardens.

Activities include:

- Develop a quick assessment to identify potential pilot projects across the Island.
- The development could include existing community centers or rehabilitation of existing structures (for example, government or public buildings such as schools).
- Select potential sites based on communities, a risk assessment, and informed by evaluating data from the Federal Communications Commission's Disaster Information Reporting System (DIRS).
- Design the centers based on community census to define geographic target area, community profile (elder people, children, people with special needs), adequate space for basic service, and community interest such as the type of social services, recreation activities.
- Pilot the Resilient Community Centers in Housing Public projects.
- Resilient Community Centers could serve as testbeds for innovations on green building design geared towards resiliency strategies (for example, solar panels with battery storage, water capture and reuse, recyclable building materials, or serve as 5G hubs).

Potential Lead

Communities;Municipality; Puerto Rico Department of Housing

Potential Co-leads

PRPB; HUD; FEMA; PSHSB; 911 Administrators; FCC's Public Safety Support Center and NGOs

Potential Funding Sources

CDBG-DR; HMGP; philanthropic funding; FCC and telecommunication providers including AT&T and Claro

Unmet Needs

Crosscutting Benefits

Timeframe

Medium term

A27 Develop a training and capacity-building program to promote local businesses and effective public participation throughout the recovery process.

Description

A training and capacity-building program could be developed using allocated Puerto Rico recovery funds to increase local jobs. This initiative can be used to boost local capacities to support recovery and reconstruction actions on technical, professional and other specialized services. Programs should focus on infrastructure sector priorities that will support the sustainable development of Puerto Rico in the long-term. Sectors include telecommunication, transportation, stormwater management, community small water systems and other sectors jobs. Training and capacity building programs can be implemented through municipalities with Community Development Building Grants – Disaster Recovery (CDBG-DR) funds that allow the development of microgrants.

Microbusinesses create jobs that foster skill development and often employ residents who are disadvantaged or excluded from traditional labor markets. Through the creation of microbusinesses, projects can be developed, maintained, and monitored. Nonetheless, there is a need to help communities and individuals develop necessary skills, primarily for the development of reconstruction projects focusing on ecosystem enhancement. The goal is to attract new businesses and capitalize on the economic potential of specific industries to rebuild the workforce, with an emphasis on creating opportunities for low- to moderate-income workers. This action will develop the market force to address the demand for landscape planning, managing organic residuals and green infrastructure solutions.

Effective participation strategies will promote fair and transparent management and performance assessments while strengthening the trust in public services. Also, critical infrastructure will better accommodate abnormal demand, withstand unusual pressures and continue functioning which allows for less disruption regarding crisis.

Potential Lead

Puerto Rico Central Office for Recovery, Reconstruction and Resilience

Potential Co-leads

DEDC; Municipalities; Universities; Telecommunication providers; PRASA; DTPW

Potential Funding Sources

USDA; FEMA; EPA; DNER

Unmet Needs

Crosscutting Benefits

Timeframe

Short term

A28 Develop an outreach and education program on domestic water treatment and storage in order to improve drinking water quality, at the point of consumption in times of emergency, for rural communities.

Description

Reliable water supply is one of the highest priority interventions in emergency situations, and it is critical to enhancing the resilience of communities and households, particularly in the rural setting. An education program on domestic/household water treatment and storage (HWTS) should be developed to secure safe water supply in times of emergency. The initiative will improve household and community emergency preparedness in case of insufficient or complete disruption of the public or community water supply system. It will help improve water quality at the point of consumption when drinking-water sources are unreliable or unsafe. The proposed measures will not replace the obligation of PRASA, local government or community service providers to provide access to safe drinking water. Recommended actions are intended to support individuals, households and communities temporarily when there are unreliable or insufficient piped supplies to bridge gaps between deliveries or in emergency situations.

Activities include:

- Implement a target group analysis to establish suitable communication methods including messages and communication channels, identify community champions, detect vulnerable communities and households, define priorities to distribute water filters and chlorine for domestic treatment, and conduct market analysis for domestic water storage and treatment equipment.
- Develop a community clean water platform that provides information on water quality and quantity, and participant communities, and provides periodic status updates with the communities for evaluating the impact of the interventions.
- Develop and implement a community and household sensitization program on domestic water storage and treatment.
- Develop specific education measures for school children and possibilities for incorporation of education measures into school curricula.

Potential Lead

Puerto Rico Environmental Quality Board

Potential Co-leads

DNER; PRASA; FEMA; EPA; PREMA; PRPB

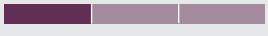
Potential Funding Sources

USDA; FEMA; EPA; DNER

Unmet Needs

Crosscutting Benefits

Timeframe



Short term

A29 Reconstruct decentralized wastewater systems to strengthen their recovery capacities.

Description

The action will minimize the vulnerability of the Island and improve the standard of living by allowing individuals, communities, and businesses with decentralized wastewater systems to access safe, reliable and affordable sanitation services. As houses continue to follow through their recovery and reconstruction processes, special attention must be given to ensure appropriate condition, operation and maintenance of decentralized wastewater systems. It improves the health and well-being of the people living on the island and protects the natural environment and sensible ecosystems. Reliable wastewater services help local business development. Improved operation of decentralized wastewater will help to prevent environmental degradation, pollution of water sources and the ocean, protect watersheds and the natural environment, and promote economic vitality.

This action involves the following activities:

- Develop an initial assessment to update building units with decentralized wastewater systems, with particular emphasis on residential units with septic sewer. This assessment will include a platform of GIS datasets to identify and select target and priority areas spatially.
- Evaluate the inventory to identify non-compliant practices across the Island and select hotspots that are susceptible to natural hazards, impacts to critical watersheds and other natural infrastructure assets, and other areas that can generate adverse impacts to public health.
- Establish monitoring and compliance activities to ensure decentralized systems are operating following existing codes. Proactive operation and management of infrastructure will ensure their quality and performance allowing the infrastructure to be compliant with regulatory requirements and perform better, accommodate abnormal demand, and withstand unusual pressures.
- Promote alternative wastewater treatment technologies to reduce chances to adverse impacts on health and natural resources, and to maximize use of by-products (e.g. bio-systems).

Potential Lead

Puerto Rico Department of Housing

Potential Co-leads

EQB; EPA; PMO; Municipalities

Potential Funding Sources

HUD CDBG-DR; EPA; USDA; FEMA

Unmet Needs

Crosscutting Benefits

Timeframe

Medium term

A30 Improve solid waste management in urban and rural communities by adopting a circular economy approach.

Description

Place-based solid waste management (SWM) programs should be implemented to reduce informal solid waste dumping and river contamination by adopting a circular economy approach. Guiding principles for creating a sustainable SWM system should be focused on long-term planning and maximizing all elements of the "triple bottom line" (i.e., economic prosperity, environmental stewardship, and social equity).

Activities steps include:

1. Evaluate Island-wide SWM goals and identify priority rural and urban communities for intervention based on clear, transparent, needs-based criteria.
2. Assessment of SWM system and gaps in priority communities by collecting relevant data and information (such as characterize waste management system, and wastes generated, current landfills conditions, population behavior, data, and growth forecast), pre-feasibility studies for pilot projects and an indicative investment plan focusing on key development and policy challenges.
3. Develop a re-thinking waste program that defines technical parameters for effective SWM in urban and remote rural communities, focuses on developing:
    - Institutional capacity.
    - Business models for best waste management practices for businesses and the public.
    - Assessment on the economics of recycling and recyclables supply.
    - New technologies for producing compost, energy, and other potentially valuable materials.
    - Actions to enhance the operation and prepare for closure of landfill sites
    - A solid waste management scorecard.
4. Develop awareness, educational and technical assitance programs to improve in-house recycling, raise willingness to pay for sustainable solutions, and best practices for waste reduction, backyard or community composting of organic waste, and recycling by businesses, local organic compost markets.
5. Establish a Permanent Advisory Committee to share information and experiences, advise the government on policies, economic opportunities, measure island wide progress and report to the public.
6. Restructure funding for solid waste services to ensure full cost recovery, create incentives, and allow communities to use a portion to fund programs that help reduce the waste disposal.

Potential Lead

Communities; Municipalities

Potential Co-leads

USDA; EPA; SWMA; FEMA; Public Assistance and CDBG-DR

Potential Funding Sources

USDA; EPA; FEMA, Public Assistance; CDBG-DR

Unmet Needs

Crosscutting Benefits

Timeframe

Short to medium term

05 RESOURCES

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Glossary

Accessible
Something that has access, and that can be reached and understood.

Adaptation
The process of adjustment to actual or expected climate and its effects as to moderate harm or exploit beneficial opportunities.

Adaptation capacity
The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities.

Affordable
Considered to be within financial means.

Aquifer
Part of a geological formation that, due to the porosity or fracturing of the material that forms and hydrological conditions, accumulates water that flows through the formation in quantities that can be extracted.

Base flood elevations (BFE)
Regulatory requirement for the elevation or floodproofing of structures based on the computed elevation to which floodwater is anticipated to rise during the base flood. BFE are shown on Flood Insurance Rate Maps (FIRMs) and on the flood profiles.

Capacity
The combination of all the strengths, attributes, and resources available to an individual, community, society, or organization, all of which can be used to achieve established goals.

Capacity building
Efforts aimed to develop human skills or societal infrastructures within a community or organization. In extended understanding, capacity building also includes development of institutional, financial, political and other resources, such as technology at different levels and sectors of the society. (UN/ISDR, Terminology: Basic Terms of Disaster Risk Reduction, March 31, 2004, p. 1).

Chronic stress
Conditions that progressively reduce the ability of individuals, businesses, institutions, and systems to function effectively.

Climate change
A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC).

Combined sewer overflow
Occurs when the sewer systems and treatment plants are unable to handle flows that are more than twice their design capacity. When this occurs, a mix of excess stormwater and untreated wastewater discharges directly into the waterways at certain outfalls to prevent upstream flooding.

Continuity of Operations (COOP) Plans
As defined in the National Continuity Policy Implementation Plan, a COOP is an effort within

individual executive departments and agencies to ensure that Primary Mission Essential Functions continue to be performed during a wide range of emergencies, including localized acts of nature, accidents, and technological or attack-related emergencies.

Cost-benefit analysis
A process used to select countermeasures by balancing the costs of implementing each option against the benefits derived from it. In general, the cost of managing risks needs to be equal to the benefits gained from the countermeasures in place. (UNDAP, Techniques Used in Disaster Risk Assessment, 2008).

Critical infrastructure
Systems and assets, whether physical or virtual, so vital that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters.

Critical systems
Systems in which a failure can cause significant economic losses, physical damage, or, in the worst cases, threats to human life.

Dam
Structure of earth, rock, concrete or any other material designed and constructed with the objective of retaining surface waters to create a reservoir, lake, pond or any other artificial water deposit.

Dependency
A linkage or connection between two infrastructures, through which the state of one infrastructure influences or is correlated to the state of the other.

Disaster
Severe alterations in the normal functioning of a community or society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Efficiency
Performing or functioning in the best possible manner with the least waste of time and effort.

Effluent
The liquid or gaseous waste discharge, generated by various human activities, that flows into collecting systems or directly to the receiving bodies.

Emergency preparedness
Actions taken to plan, organize, equip, train, and exercise with the objective of building and sustaining the capabilities necessary to prevent, protect against, mitigate the effects of, respond to, and recover from those threats that pose the greatest risk.

Exposure
The presence of people, livelihoods, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected.

Flexibility
Flexibility implies that systems can change, evolve and adapt in response to changing circumstances. This may favor decentralized and modular approaches to infrastructure or ecosystem management. Flexibility can be achieved through the introduction of new knowledge and technologies, as needed. It also means considering and incorporating indigenous or traditional knowledge and practices in new ways.

Flood risk management
Processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of flood risk, foster flood risk reduction and transfer, and promote continuous improvement in flood preparedness, response, and recovery practices. They have the explicit purpose of reducing the likelihood and/or the impact of floods in order to prevent the loss of properties, assets and life caused by floods.

Geographic Information System (GIS)
A framework for gathering, managing, and analyzing data and spatial location. It uses maps to organize layers of information into visualizations. Rooted in the science of geography, GIS integrates many types of data.

Governance
Structures and processes designed to ensure accountability, transparency, responsiveness, rule of law, stability, equity and inclusiveness, empowerment, and broad-based participation. Governance also represents the norms, values, and rules of the game through which public affairs are managed in a manner that is transparent, participatory, inclusive, and responsive.

Grant programs
Programs that provide a sum of money given by a government or other organization for a particular purpose. These programs are discretionary, or formula grants and/or cooperative agreements administered by a federal agency.

Gray infrastructure
Human-engineered infrastructure for water resources, such as water and wastewater treatment plants, pipelines, and reservoirs.

Gray water
All wastewater generated in households or office buildings from streams without faecal contamination (i.e. all streams except for the wastewater from toilets).

Green infrastructure
An approach to water management that protects, restores, or mimics the natural water cycle. Green infrastructure is typically a network of natural lands, working landscapes, and other open spaces to conserve ecosystem values and functions and provide associated benefits to human populations.

Green jobs
Jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources. These jobs also include duties involved in making an establishment's production processes more environmentally friendly or use fewer natural resources.

Groundwater
The waters that are in a geological formation or unit below the surface of the earth (i.e., under the bed of a river, creek or stream, or under the sea, lake, dam or other body of water) independently of what is its origin or state, or the formation or geological unit in which they are, flow, percolate or move.

Hard infrastructure
The physical infrastructure of roads, bridges, etc., as opposed to the soft infrastructure of human capital and the institutions that cultivate infrastructure.

Heat island (also heat island effect)
An urban area characterized by temperatures higher than those of the surrounding non-urban area. As urban areas develop buildings, roads, and other infrastructure that replace open land and vegetation, these surfaces absorb more solar energy, which can create higher temperatures in urban areas.

Hydrologic cycles
The cycle in which water evaporates from the oceans and the land surface, is carried over the Earth in atmospheric circulation as water vapor, condenses to form clouds, precipitates again as rain or snow, is intercepted by trees and vegetation, provides runoff on the land surface, infiltrates into soils, recharges groundwater and/or discharges into streams and flows out into the oceans, and ultimately evaporates again from the oceans or land surface.

Inclusive
Emphasizes the need for consultation and commitment of communities, including the most vulnerable groups. Addressing the shocks and stresses faced by a sector, location or community that is isolated from others is an exclusion for the notion of resilience. An inclusive approach contributes to a sense of shared ownership or a joint vision to build a system's resilience.

Infrastructure
Set of works and services that are considered fundamental and necessary for the establishment and operation of an activity. These include communication systems, aqueducts and sewers, electricity, telephone and health facilities, education, and recreation.

Integrated
Integration and alignment between systems promotes consistency in decision-making and ensures that all investments are mutually supportive to a common outcome. Integration is evident within and between resilient systems and across different scales of their operations. Exchange of information between systems enables them to function collectively and respond rapidly through shorter feedback loops throughout society.

Interdependency
A bidirectional relationship between two infrastructures through which the state of each infrastructure influences, or is correlated to, the state of the other. More generally, two infrastructures are interdependent when each is dependent on the other.

Internet of things (IoT)
As a global infrastructure for the information society, that enables advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

Landslide
A mass of material that has moved downhill by gravity, often assisted by water when the material is saturated. The movement of soil, rock, or debris down a slope can occur rapidly, or may involve slow, gradual failure.

Levee
An embankment built to prevent the overflow of a river.

Mitigation (for risk)
The lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability. (for Climate Change) A human intervention to reduce the sources or enhance the sinks of greenhouse gases.

Non-point source
Discharge of a fluid or material spread over a large area from multiple sources, rather than at a specific point.

Non-governmental Organization (NGO)
An entity with an association that is based on interests of its members, individuals, or institutions. It is not created by a government, but it may work cooperatively with government. Such organizations serve a public purpose, not a private benefit.

Nonprofit organization
A tax-exempt organization that serves the public interest. In general, the purpose of this type of organization must be charitable, educational, scientific, religious, or literary. It does not declare a profit and utilizes all revenue, available after normal operating expenses, in service to the public interest. This organization is a 501(c)(3) or a 501(c)(4) designate.

Operation and maintenance
A broad spectrum of services, competencies, processes, and tools required to assure the built environment will perform the functions for which a facility, assets and systems were designed and constructed.

Place based infrastructure
Infrastructure developed based on a vision for a place and on a shared understanding of local challenges and co-produced with the local individuals and community.

Point source
Any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack.

Potable water
Water that has been purified for human consumption,

according to the quality standards specified in the Safe Drinking Water Act.

Primary treatment
Process of partially purifying wastewater using physical means. This treatment removes 80 percent of the suspended solids in the water and 35 percent of the biological oxygen demand (BOD).

Public-private partnerships
A cooperative arrangement between two or more public and private entities, typically of a long-term nature. These partnerships between a government agency and private-sector company can be used to finance, build, and operate projects, such as public transportation networks, parks, and convention centers.

Rainwater harvesting
Collection of run-off from a structure or other impervious surface in order to store it for later use.

Reconstruction
The reconstruction or replacement of permanent residential, commercial, or industrial facilities damaged or destroyed in a major disaster, as well as the construction of public or private infrastructure at large scale, the addition of community improvements, and/or the restoration of a healthy economy.

Recovery
Disaster recovery is the phase of the emergency management cycle that begins with the stabilization of the incident and ends when the community has recovered from the impacts of the disaster.

Redundant
Refers to spare capacity purposely created within systems so that they can accommodate disruption, extreme pressures or surges in demand. It includes diversity: the presence of multiple ways to achieve a given need or fulfil a particular function. Examples include distributed infrastructure networks and resource reserves. Redundancies should be intentional, cost-effective, and prioritized at a society scale.

Reflective
Accepts the inherent and ever-increasing uncertainty and change in today's world. Reflective systems have mechanisms to continuously evolve and modify standards or norms based on emerging evidence, rather than seeking permanent solutions based on the status quo. As a result, people and institutions examine and systematically learn from their past experiences and leverage this learning to inform future decision-making.

Regulatory frameworks
Frameworks that provide the base on which institutions build and determine the scope and nature of participation in society. It is a complex combination of statutes and legal regulations, judicial rules, and actual practice.

Renewable energy
Energy, derived from natural processes (i.e., sunlight or wind), that are replenished at a faster rate than they are consumed. Solar, wind, geothermal, hydroelectric and some forms of biomass are common sources of renewable energy.

Reservoir
A natural or artificial pond or lake used to store water.

Resilience
The capacity of individuals, communities, institutions, businesses, and systems to survive, adapt and thrive no matter what stresses or shocks they encounter.

Resilience dividend
The net social, economic, and physical benefits achieved when designing initiatives and projects in a forward looking, risk-aware, inclusive, and integrated way.

Resourceful
Implies that people and institutions are able to rapidly find different ways to achieve their goals or meet their needs during a shock or when under stress. This

may include investing in capacity to anticipate future conditions, set priorities, and respond, for example, by mobilizing and coordinating wider human, financial and physical resources. Resourcefulness is instrumental to a society's ability to restore functionality of critical systems, potentially under severely constrained conditions.

Risk
Potential consequences in which something of value is in danger with an uncertain outcome, recognizing the diversity of values. Often, risk is represented as the probability of occurrence of dangerous events or trends multiplied by the impacts in case such events or trends occur. Risks result from the interaction of vulnerability, exposure, and danger.

Risk assessment
The determination of quantitative or qualitative estimate of risk related to a well-defined situation and a recognized threat or hazard. The assessment includes the calculations of the risk magnitude, potential loss, and the probability that the loss will occur.

Robust
Robust systems include well-conceived, constructed and managed physical assets that can withstand the impacts of hazard events without significant damage or loss of function. Robust designs anticipate potential system failures and ensure failure is predictable, safe, and not disproportionate to the cause.

Runoff
Part of precipitation that does not evaporate and is not transpired but flows through the ground or over the ground surface and returns to bodies of water.

Sea level rise
An increase in global mean sea level as a result of an increase in the volume of water in the world's oceans. The two major causes of global sea level rise are thermal expansion caused by warming of the ocean (since water expands as it warms) and increased melting of land-based ice, such as glaciers and ice sheets.

Secondary treatment
Process of partially purifying wastewater using physical and biological media, removing up to 95 percent of the biochemical oxygen demand (BOD) and total suspended solids in wastewater.

Shock
Sudden, sharp events that threaten a society, including earthquakes, floods, disease outbreaks, and terrorist attacks.

Storm surge
An abnormal rise in sea level accompanying a hurricane or other intense storm and whose height is the difference between the observed level of the sea surface and the level that would have occurred in the absence of the cyclone.

Stormwater (urban runoff)
Runoff generated from rain events that flow over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground. The runoff picks up pollutants like trash, chemicals, oils, and dirt/sediment that can harm our rivers, streams, lakes and coastal waters, and cause urban flooding.

Surface waters
The waters that run continuously or discontinuously on public or private lands, or that are found in lakes, reservoirs or any other body of water on the land surface.

Susceptibility
Society's and ecosystems' predisposition to suffer as a result of intrinsic and contextual conditions for make it plausible that such systems to collapse or experience damage due to the influence of a dangerous event.

Sustainable development
Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainability has emerged as the guiding principle for long-term global development. Consisting of three pillars, sustainable development seeks to achieve, in a balanced manner, economic development, social

development, and environmental protection.

Tertiary treatment
Advanced treatment of sanitary water that is a continuation of primary and secondary treatments. Removes 99 percent of pollutants from wastewater.

Unmet needs
The needs of communities or families that have not been attended by federal government institutions as a result of a disaster.

Vulnerability
The propensity or predisposition to be adversely affected. Vulnerability comprises a variety of concepts and elements that include sensitivity or susceptibility to harm and lack of responsiveness and adaptation.

Vulnerable populations
Groups and communities at higher risk as a result of barriers they experience to social, economic, political and environmental resources, as well as limitations due to illness or disability.

Wastewaters
Waters that human beings have used in domestic, agricultural and industrial activities, and that, as a result, contain contaminants that make them unfit for certain uses, such as consumption and contact with human skin.

Watershed
A land area that channels rainfall to creeks, streams, groundwater and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean.

Wetlands
Terrestrial or estuarine ecosystems where the land is flooded most of the time; however, a wetland regulation constitutes any area where the land maintains a certain amount of water, which does not imply flooding. Wetlands fulfill fundamental ecological functions, including regulators of hydrological regimes and habitats of abundant biodiversity.

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06 APPENDIX

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Methodological Approach

The Commission's main objective is to produce an actionable and time-sensitive set of recommendations to guide the use of philanthropic, local government, and federal recovery funds to repair and rebuild the critical systems devastated by Hurricane María and build back an Island more physically, economically, and socially resilient. To achieve this, the Commission applied two primary conceptual frameworks to guide the process of reimagining Puerto Rico's recovery and reconstruction: FEMA's National Disaster Recovery Framework[10] and The Rockefeller Foundation's City Resilience Framework[11].

FEMA's National Disaster Recovery Framework (NDRF) establishes a common platform and forum for a comprehensive approach to how a community builds, sustains, and coordinates the delivery of recovery efforts. Under this framework, the concept of recovery under this framework includes the restoration and strengthening of key systems and resources that are critical to the economic stability, vitality, and long-term sustainability of communities. These recovery elements are organized and coordinated under six Recovery Support Functions: 1) community planning and capacity building; 2) economic recovery; 3) health and social services; 4) housing; 5) infrastructure systems; and 6) natural and cultural resources. In the aftermath of Hurricanes Irma and María in 2017, this framework will guide all federal disaster recovery actions coordinated by FEMA, in close coordination with other federal and Puerto Rican agencies.

The NDRF advances the concept that recovery extends beyond merely repairing damaged structures. It also includes the continuation or restoration of services critical to supporting the physical, emotional, and financial well-being of impacted community members. Among these are: health (including behavioral health) and human services capabilities and networks, public and private disability support and service systems, educational systems, community social networks, natural and cultural resources, affordable and accessible housing, infrastructure systems, and local and regional economic drivers. In turn, these elements contribute to rebuilding resilient communities equipped with the physical, social, cultural, economic, and natural infrastructure required to address future needs.

Arup and The Rockefeller Foundation's City Resilience Framework (CRF) provide a more comprehensive vision of how resilience can be integrated into Puerto Rico's post-disaster recovery process. The CRF, while focused on a city scale, provides a conceptual framework of resilience that is applicable across different geographical scales, including small island nations. This framework identifies seven resilience qualities: inclusive, integrated, flexible, redundant, reflective, resourceful,

Lajas, PR. Hector Cortés

and robust. In addition to these qualities, it suggests that resilience can be enhanced by addressing a combination of 12 factors categorized under four broad dimensions: I) health and well-being of individuals, II) economy and society, III) infrastructure and ecosystems, and IV) leadership and strategy. The 12 factors include: 1) effective safeguards to human health and life; 2) diverse livelihoods and employment; 3) minimal human vulnerability; 4) reliable mobility and communications; 5) effective provision of critical services; 6) reduced exposure and fragility; 7) sustainable economy; 8) comprehensive security and rule of law; 9) collective identity and community support; 10) effective leadership and management; 11) empowered stakeholders; and 12) integrated development planning (see Figure 6).

The NDRF served as the main framework to guide the planning of implementation, execution, and monitoring of recovery and reconstruction actions. To reinforce this approach, we employed a modified version of the CRF to analyze and prioritize the recovery and reconstruction actions with the highest resilience impact.

As described in Section I, the Commission embarked on an ambitious participatory process in order to achieve the primary goals and objectives set forth for ReImagina Puerto Rico. This process consisted of four sets of group meetings: the Public Sector Advisory Group, Sector-focused Working Groups, Community Focus Groups, and Youth Participatory Photography sessions. This process sought to bring the broadest and most diverse set of voices together, facilitating an essential conversation between students, community groups, business sector representatives, high-level government officials, academics, and other Puerto Rican leaders to reimagine a more resilient Puerto Rico.

High-level officials from key local government agencies and several rural and urban municipalities representing the main political parties within the Island comprised the Public Sector Advisory Group. Participants included representatives from the Puerto Rico Planning Board, the Puerto Rico Department of Housing, the Puerto Rico Central Office of Recovery, Reconstruction, and Resilience, the Puerto Rico representative to the Financial and Oversight Management Board, and the mayors of Bayamón, Carolina, Cidra, and Villalba, among other active participants.

F3 CITY RESILIENCE FRAMEWORK. THIS GRAPHIC REPRESENTS THE MAIN RESILIENCE DIMENSIONS WITH ITS 12 ASSOCIATED FACTORS, AS WELL AS THE SEVEN RESILIENCE QUALITIES.

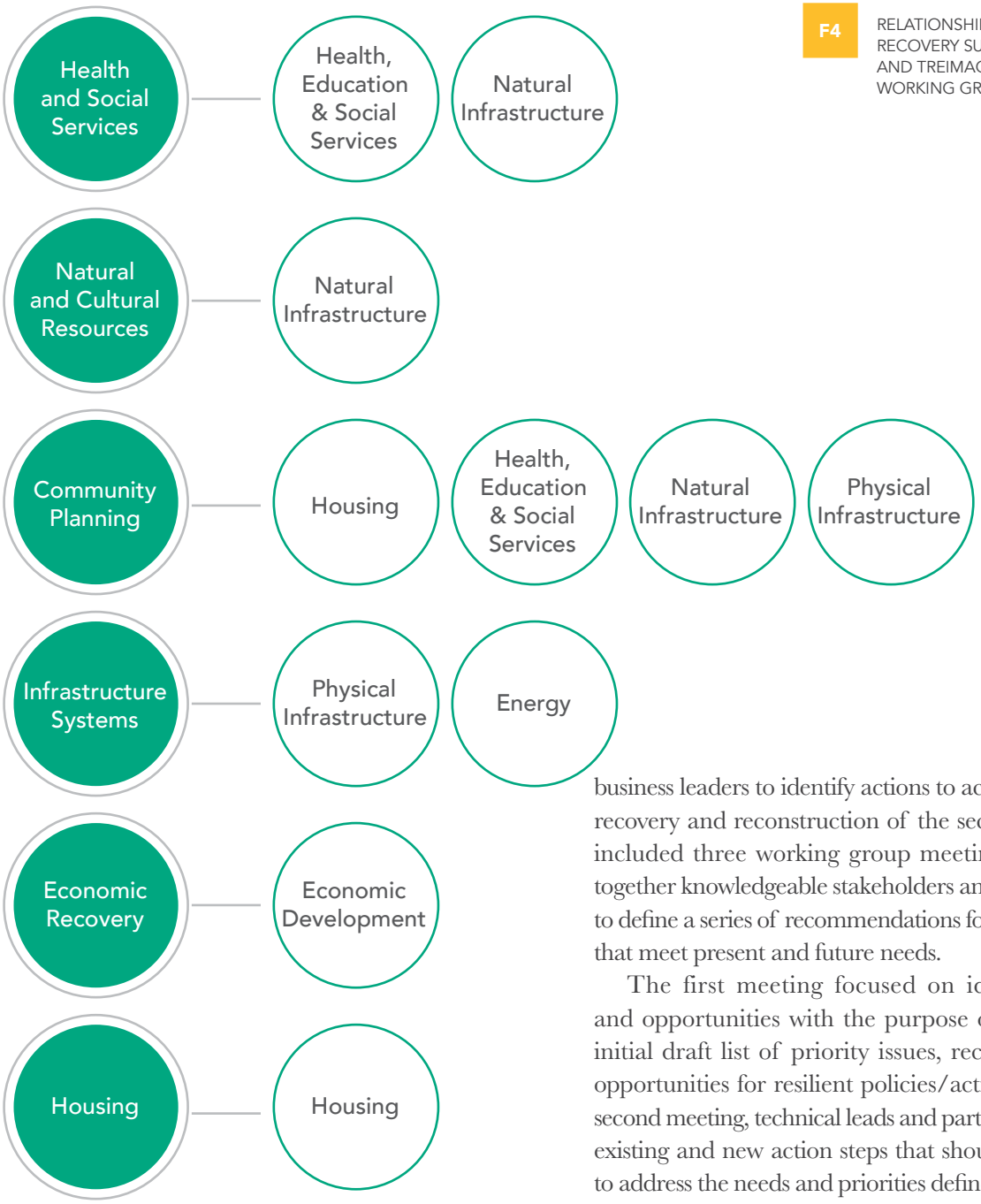
1. Effective leadership & management
2. Empowered stakeholders
3. Integrated development planning

4. Minimal human vulnerability
5. Diverse livelihoods & employment
6. Effective safeguards to human health & life

10. Reduced exposure and fragility
11. Effective provision of critical services
12. Reliable mobility & communications

7. Collective identity & community support
8. Comprehensive security & rule of law
9. Sustainable economy

F4 RELATIONSHIP BETWEEN THE NDRF RECOVERY SUPPORT FUNCTIONS AND TREIMAGINA PUERTO RICO'S WORKING GROUPS



The Commission divided working groups into the following six key sectors: 1) Housing, 2) Energy, 3) Physical Infrastructure, 4) Health, Education & Social Services, 5) Economic Development, and 6) Natural Infrastructure. These sectors have direct linkages to all the Recovery Support Functions under the NDRF, as described in Figure 7.

The purpose of the working groups was to facilitate a technical discussion among Puerto Rico experts and business leaders to identify actions to achieve the resilient recovery and reconstruction of the sector. This process included three working group meetings that brought together knowledgeable stakeholders and thought leaders to define a series of recommendations for recovery actions that meet present and future needs.

The first meeting focused on identifying needs and opportunities with the purpose of generating an initial draft list of priority issues, recovery goals, and opportunities for resilient policies/actions. Prior to the second meeting, technical leads and participants presented existing and new action steps that should be considered to address the needs and priorities defined during the first meeting. The second meeting focused on the developing and distinguishing actions that were identified s having the highest potential for impact within each working group, taking into consideration possible interdependancies. During the third meeting, participants refined the proposed recommendations and applied the resilience lens to those actions in order to guide the final recommendations.

The process of developing recommendations for the resilient recovery of Puerto Rico entailed the following analysis criteria of the Island's unique context:

The urban/rural divide on the Island, recognizing that resilient economic development opportunities for rural communities are as essential as the opportunities in the Island's urban centers.

How recommended actions reflect on resilience qualities (e.g., inclusive, integrated, flexible, redundant, reflective, resourceful, robust).

Issues of equity, transparency, and sustainability.

The variety of ecosystems present in the Island and the challenges and opportunities they each present. It is imperative, for example, to consider the state of adaptive capacity of coastal and inland forest ecosystems to continue to provide ecosystem services in a changing climate.

The social, economic and geographic realities of Puerto Rico (e.g., Is the recommendation fundable? Is it culturally acceptable? Is it politically feasible?).

A recognition that Puerto Rico is bounded by water, and its associated exposure to climate hazards, its dependency on a specialized industry, its overreliance on importing of goods and limited natural resources, and the high cost of infrastructure.

Manatí, PR. Cristina A. Fawaz López

F5 REIMAGINA PUERTO RICO'S PARTICIPATORY PROCESS. THE DIVERSE SET OF MEETINGS AND DISCUSSIONS HELD BETWEEN THE PUBLIC SECTOR ADVISORY GROUP, THE WORKING GROUPS, AND THE COMMUNITY FOCUS GROUPS HELPED CREATE AND VALIDATE THE INFORMATION PRESENTED IN THIS REPORT.

The Community Outreach and Engagement Process was divided into two sets of activities held in six distinct regions of the Island. These regions were strategically selected to cover all areas of the Island, including the urban/rural divide and other geographical, social, and cultural regional characteristics.

The first activity was the Youth Participatory Photography, which was held in six distinct schools across the Island (one in each region). During this activity, students had the opportunity to identify assets they believe are essential to maintain and improve their communities. The objective of the Youth Participatory Photography activities was to allow students to identify, through photography, remarkable resilience and recovery challenges in their communities. This process included a forum where students could display and present their photos. During this forum family members and other residents commented and elaborated on the importance of changing or improving specific aspects of their communities after the hurricanes.

The second Community Outreach and Engagement activity of community engagement consisted of

Community Focus Groups in each of the six regions. Two additional Focus Group Sessions were conducted, one for philanthropic and non-governmental organizations and another for the Puerto Rican diaspora in Orlando, Florida, where most Puerto Ricans have migrated to in the past year. The objective of the Focus Groups was to incorporate their voice in the development of the report, understand the Island-wide perspectives on recovery and resilience, and validate the Working Groups' outcomes through participatory activities and prioritization processes. During these meetings, participants expressed their issues and concerns regarding the hurricane impacts, they talked about opportunities to consider, and they validated the results from the Working Groups. Their outputs were used to elaborate and refine the needs, goals, opportunities, and actions of each Working Group.

The information derived from the Community Outreach and Engagement Process formed an integral part of the discussions in the Working Group meetings, and, ultimately, served as the basis for the recommendations presented in this report (see Figure 8).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