



RE↑MAG↑NA Puerto Rico

Resilient Puerto Rico Advisory Commission

NATURAL INFRASTRUCTURE

SECTOR REPORT

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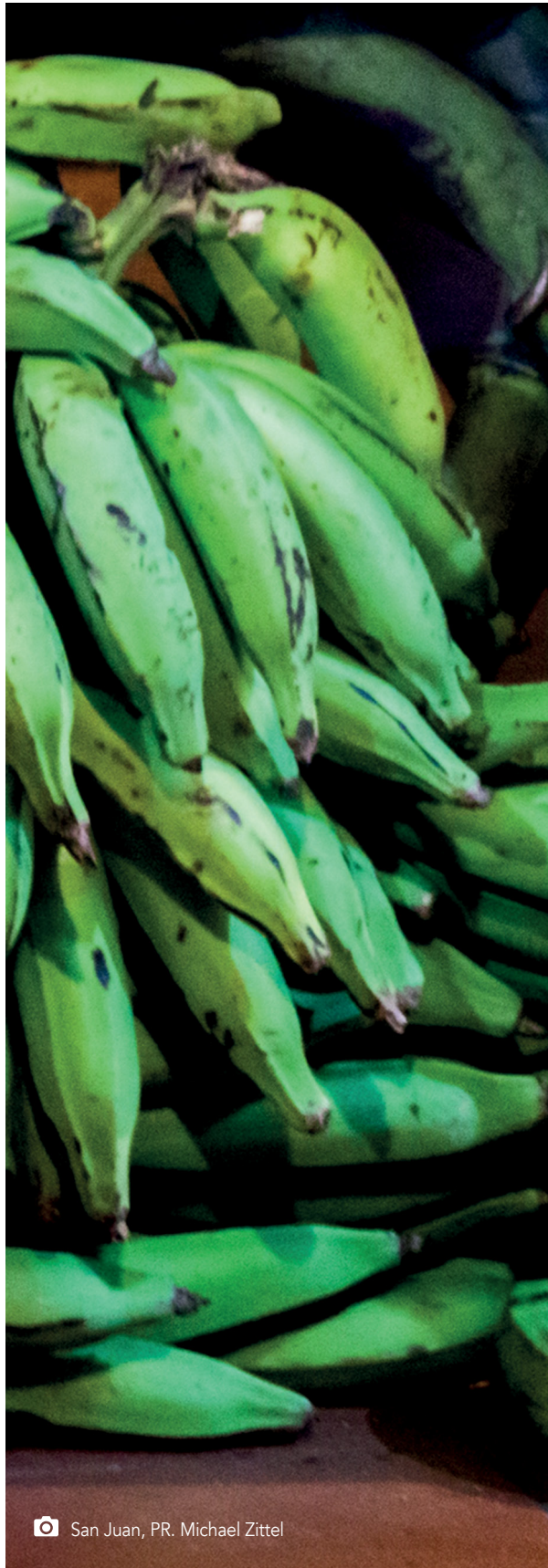
Opportunity Actions



Resources



Appendix



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

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 Center

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 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 Wages

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



01

BACKGROUND

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 recover¹. 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 2017³. Changing demographic patterns have resulted in reductions in the Island's⁴ overall population, and in an increase in the elderly and the islanders



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 States⁶.

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 declaration⁷ 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 solely 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.

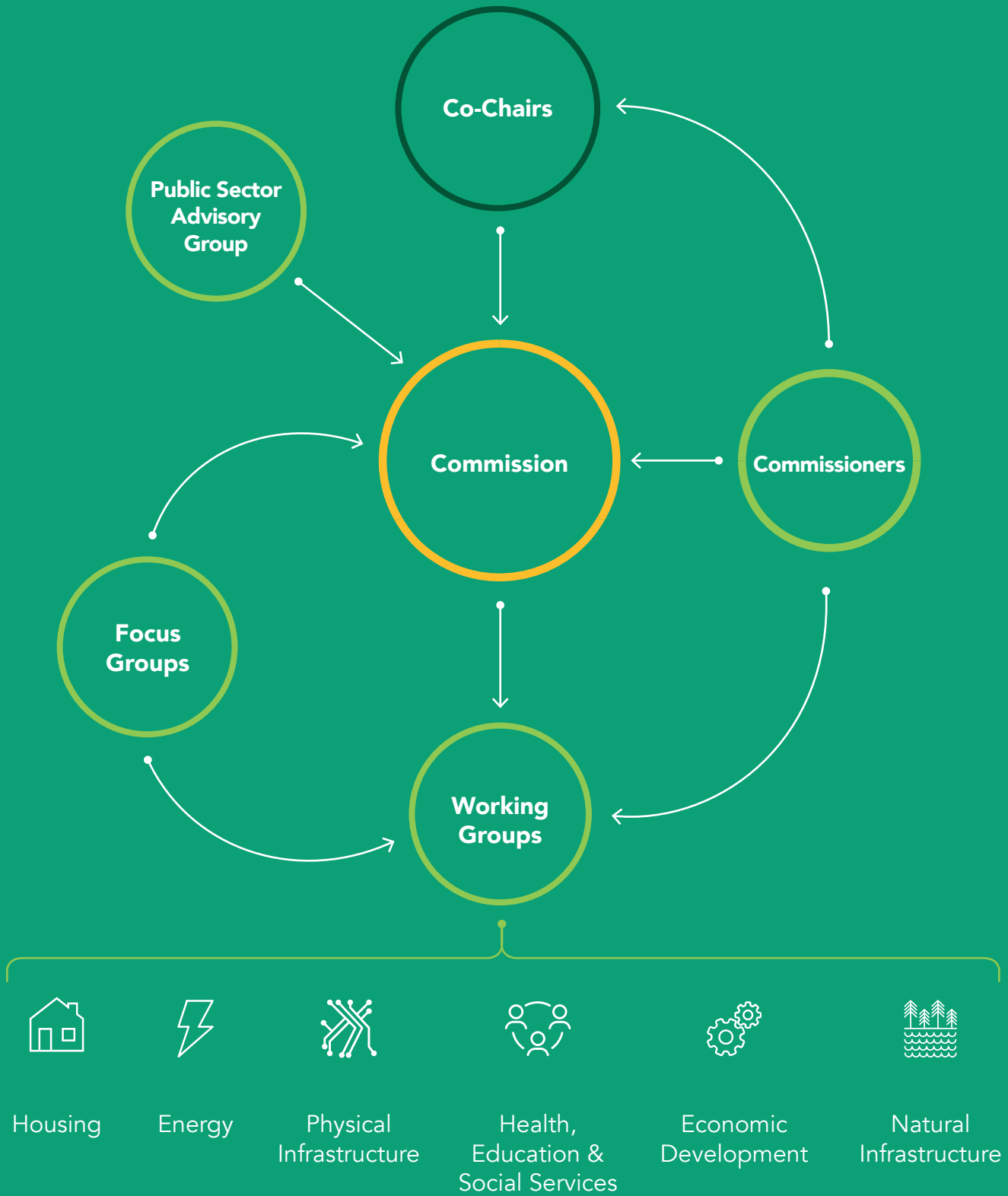
About the Resilient Puerto Rico Advisory Commission

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.





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.

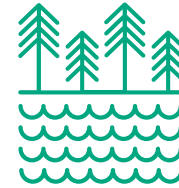




HOUSING



ENERGY

PHYSICAL
INFRASTRUCTUREHEALTH, EDUCATION &
SOCIAL SERVICESECONOMIC
DEVELOPMENTNATURAL
INFRASTRUCTURE

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 Natural Infrastructure Working Group was to provide technical guidance related to coastal and marine resources, freshwater resources, forests, and agriculture.

The Natural Infrastructure Working Group served as an advisory group to the Commission providing input on issues related to the resilience and disaster recovery of Puerto Rico's natural infrastructure. The mission of the Natural Infrastructure Working Group was to provide technical guidance related to

coastal and marine resources, freshwater resources, forests, and agriculture. The Natural Infrastructure Working Group consisted of local technical experts from federal and Commonwealth agencies, NGOs, academia, and individuals with relevant experience and expertise.

1



During the first meeting, the working group identified shocks, stresses, issues and concerns, and priority areas for the sector. Also, the working group drafted goals and objectives.

2



During the second meeting, the group members identified priority actions individually, which they discussed and fine-tuned later in the group. Needs and recommendations that emerged from the community engagement process were used to refine the work and to select priorities.

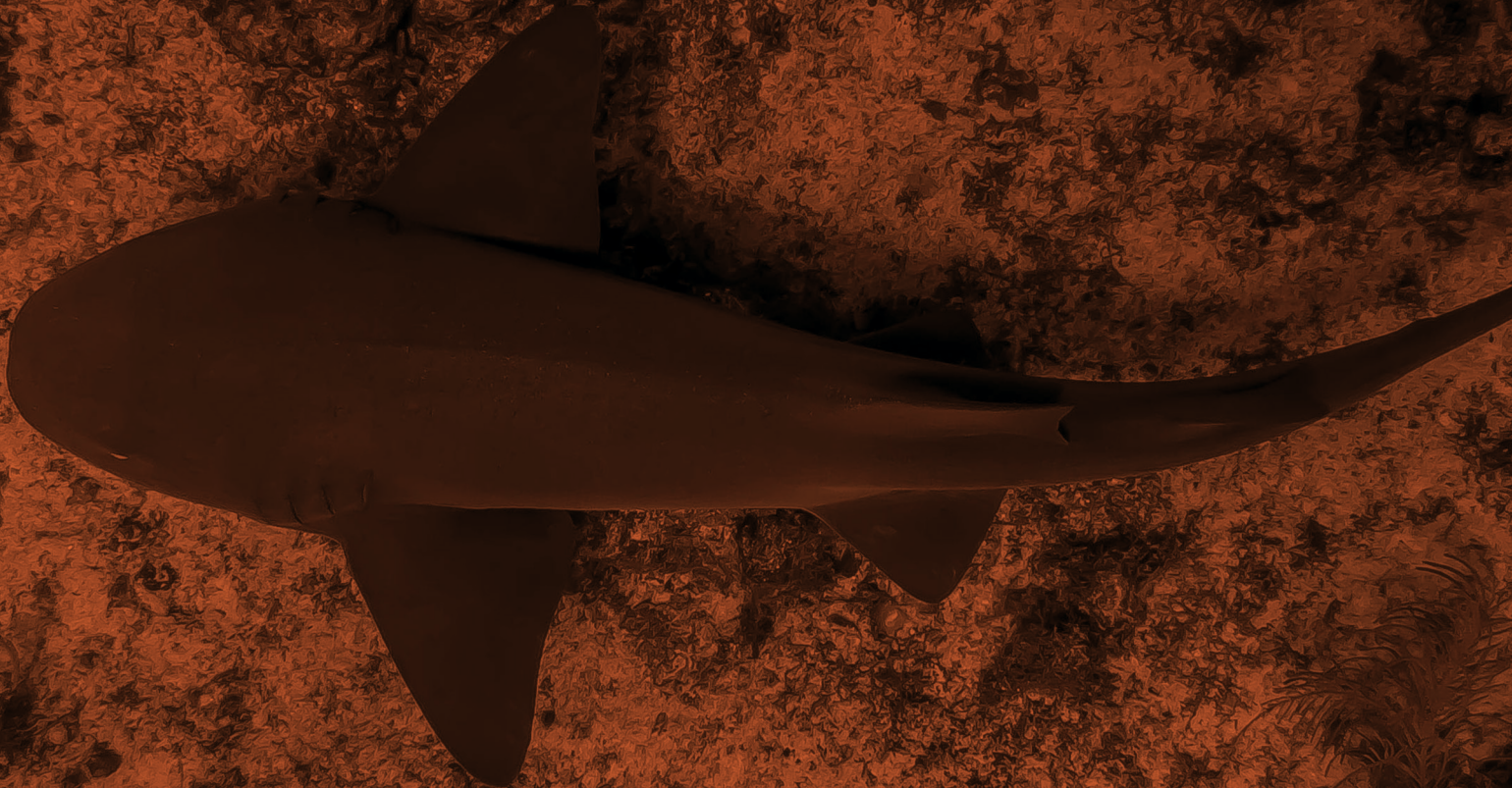
3



During the third meeting, the Natural Infrastructure Working Group assessed, selected and prioritized the final set of actions included in this report.

02

SECTOR
CONTEXT



Pre-Disaster Context

The natural infrastructure of Puerto Rico encompasses marine, coastal, freshwater, and forest ecosystems, and provides a variety of goods and services to society, such as food, recreation, and hazard protection. Robust natural infrastructure is essential for the economic, physical, and social development of Puerto Rico, as well as for the success of local agriculture.

Puerto Rico's ecosystems have been exposed to several natural and anthropogenic shocks and stresses, further described below, with climate change and ineffective land use planning as the primaries among them. The impacts of climate change - such as extreme heatwaves, a probable increase in regional downpours, increases in sea surface temperature, ocean acidification, and sea level rise - are progressively compromising the Island's ability to address economic and social priorities⁸. Increasingly variations in the hydrological cycles are causing marked rainfall reductions at times, and extreme rainfall events at others. These fluctuations have caused, and will continue to cause, adverse impacts on wetlands, marine resources, and surface and underground freshwater bodies.

In Puerto Rico, the lack of sustainable land-use planning is one of the most significant challenges

ahead - in terms of protecting and rehabilitating natural infrastructure – as well as combating climate change. It urgently needs to be addressed by the federal, state and local governments and communities. Unsustainable land-use and the destruction of ecosystems have caused habitat loss and degradation, placing additional threats to life and property in communities living in former wetland areas, coastal and floodplains that are naturally prone to flooding. These practices have also contributed to compromising our critical infrastructure, such as roads, electricity, and water, causing inefficiencies, failures and limited capacity to sustain impacts from natural hazard events. Poor land-use practices have also affected biodiversity and contributed to putting some endemic species in peril, such as the Puerto Rican parrot (*Amazona vittata vittata*) and the Puerto Rican crested toad (*Peltophryne lemur*), among others others. In Puerto Rico, 84 species of fauna and 48 species of flora are classified with “greatest conservation need” under the Commonwealth laws. Twenty-eight species of fauna and 49 of flora are listed under the Endangered Species Act⁹.

Coastal and marine resources

In
Puerto Rico

 **84** species of
fauna

 **48** species of
flora

Are classified with 
"GREATEST CONSERVATION NEED"



28 species of **fauna**
49 species of **flora**
are listed under the
Endangered Species Act

The coastal and marine ecosystems are diverse and include wetlands, dry forests, and littoral habitats¹⁰. Wetlands are among the most productive habitats on the coast, where freshwater wetlands predominate over saline¹¹. Herbaceous vegetation dominates freshwater wetlands which seasonally flood. The forested coastal wetlands cover approximately one percent of the Commonwealth's territory, of which 67 km² are mangroves, and 2.6 km² are *Pterocarpus* swamps (Gould et al., 2007). There are 1,255 beach units in Puerto Rico's 799 coastal miles. Sandy beaches with dune formations predominate in the north coast¹².

The tropical waters that surround Puerto Rico maintain suitable conditions for the development of a diversity of marine ecosystems that include seagrasses and coral reefs. Over 5,000 km² of shallow reefs surround Puerto Rico¹³.

Puerto Rico's coastal waters have failed to meet water quality standards particularly for enterococci, turbidity, low levels of dissolved oxygen, and pH, according to the latest water quality assessment conducted by the Puerto Rico Environmental Quality Board in 2016¹⁴. Sediment loads, nutrients, and other pollutants into the waters, are a major stress on the coral ecosystems and associated environments. Also, coral diseases and bleaching (caused by the continuous increase in ocean temperatures) and physical damage (caused by propellers, anchorage, and stranding of vessels) have significantly reduced live coral coverage. Water quality also affects recreational opportunities and fishing activities.

The coasts, especially in the north and west, are exposed to swells produced by cold fronts and low-

1% FORESTED COASTAL WETLANDS COVER APPROXIMATELY
of the Commonwealth's territory



67 km²

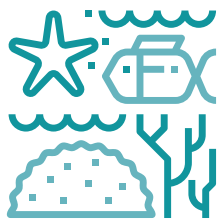
are mangroves

2.6 km²

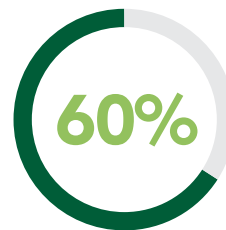
are *Pterocarpus* swamps



There are **1,255 beach units** in Puerto Rico's **799** miles of coast



Over **5,000 km²**
of shallow reefs
surround Puerto Rico



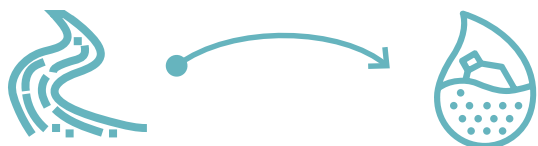
About **60%** of Puerto Rico's beaches exhibit problems

pressure systems, which can contribute to severe beach erosion impacts. An analysis published in 2017 found that approximately 60 percent of Puerto Rico's beaches exhibit continuous erosion problems, with the higher rates (from 1.04 to 1.94 meter/year) seen in Loíza, Arroyo, Humacao, San Juan, Arecibo, Isabela, Toa Baja, and Dorado¹⁵. Rincón has also experienced long-term erosion, impeding access to the beach and causing failure of properties along the coast. Other coastal areas, particularly in the southeast, are more susceptible to the effects of storm surge. While low-lying areas are vulnerable to sea level rise, even areas further from the coast, where the water table is high, are exposed to "nuisance flooding" during high tide. This type of flood events has begun to have an impact on people living in the areas of San Juan (Condado area) and Aguadilla (town center).



Sandy beaches with dune formations **predominate in the north coast**

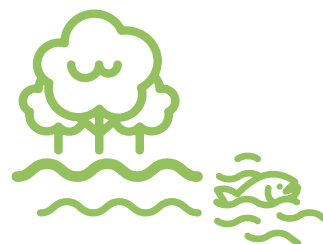
Freshwater resources



In 2016,

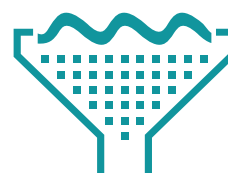
3,251 miles
of rivers and streams **failed**
to comply with water
quality parameters

Puerto Rico has surface and underground freshwater resources. Freshwater resources have also been affected by land-use change and hydromodifications, such as dams and river channeling. River channeling has degraded riverine habitat structure and function and, in many instances, created or aggravated flooding problems. In 2016, 3,251 miles of rivers and streams failed to comply with various water quality parameters, including coliform, turbidity, and phosphate¹⁶. Approximately 7,323 acres of reservoirs reported non-compliance with water quality standards for aquatic life and drinking water use¹⁷. In reservoirs, sedimentation is one of the main problems. Sedimentation decreases a reservoir's capacity to store water, reduces water quality for human and wildlife consumption and increase water treatment costs. Reservoirs receive most sediment during extreme events, such as heavy rainfall or hurricanes. This loss of reservoir capacity has contributed to the potential for long-term water-supply problems.



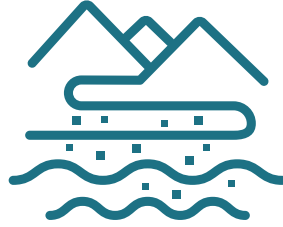
Approximately

7,323 acres
of reservoirs reported
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with water
quality standards



Sedimentation

decreases a reservoir's
capacity to **store water,**
reduces water quality,
and increases water
treatment costs



The most crucial groundwater resources in Puerto Rico are the **north coast aquifers, the south coast aquifers and the Caguas, Juncos and Cayey valley aquifers**

Aquifers

Aquifers are essential freshwater habitats in Puerto Rico. The most crucial groundwater resources in Puerto Rico are the north coast aquifers, the south coast aquifers and the Caguas, Juncos and Cayey valley aquifers¹⁸. Groundwater quality and quantity are susceptible to precipitation, runoff, the permeability of soils and sea level change. In the north coast, various wells and aquifer sites were declared Superfund sites by the U.S. Environmental Protection Agency (EPA) due to the contamination of their waters with chemicals and volatile substances from nearby industries. Superfund is a United States federal government program designed to fund the clean-up of sites contaminated with hazardous substances and pollutants. Sites managed under this program are referred to as “Superfund” sites. It was established as the United States Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Pub.L. 96–510, approved on December 11,

1980. 42 U.S.C. § 9601 et seq. Remediation processes are in different stages; some have not yet started¹⁹. The low-land elevation of the north coast aquifers makes it more susceptible to saltwater intrusion than those of the south, east, or west coast²⁰. The south coast aquifer is especially at risk due to reduced recharge to the local aquifer with the cessation of sugarcane cultivation; below-average rainfall; and relatively constant groundwater withdrawals for public supply, agriculture, and industrial use²¹. As a result, the water table is low, and less water reaches the coastal wetlands. The south coast aquifer is the primary source of potable water for the municipalities of Salinas, Santa Isabel, Coamo, and Guánica, and it is the freshwater source that sustains the Jobos Bay National Estuarine Reserve, the only in Puerto Rico and the Caribbean^{22,23}. The aquifers of the interior valleys are also susceptible to changes in precipitation and land uses.

Forests



Forest coverage in
Puerto Rico is around
58.9%

Forest coverage in Puerto Rico is around 58.9 percent²⁴. Approximately 68 percent of the forest coverage are young secondary forests, and 12 percent are mature forests. Although forest coverage has increased during the past decades, forest fragmentation is still one of the main threats to forest resources²⁵. In urban areas, particularly in the San Juan metropolitan area, tree coverage has been reduced for urban expansion. The clearing and fragmentation of forests have had a negative impact on water quality, wildlife, and other ecosystems' functions. As a result, urban floods and the heat-island effect have also increased.

Hurricanes are one of several natural disturbances that affect forest ecosystems. The impact of this type of atmospheric phenomena on Caribbean forests include tree mortality, falling of trees by uprooting and snapping, the variation of food supplies for animal populations and direct damage to a proportion of their individuals, modification of the microclimate, and the dynamics of seed and seedling banks²⁶. However, much of Puerto Rico's subtropical dry forests will remain resilient to hurricanes. Recent research concluded that changes in storm intensity alone would not largely affect the long-term forest structure and productivity. However, if hurricane frequency increases significantly, forests will not have enough time to regenerate²⁷.



Approximately
68% are **young
secondary forests**



 12% are **mature
forests**



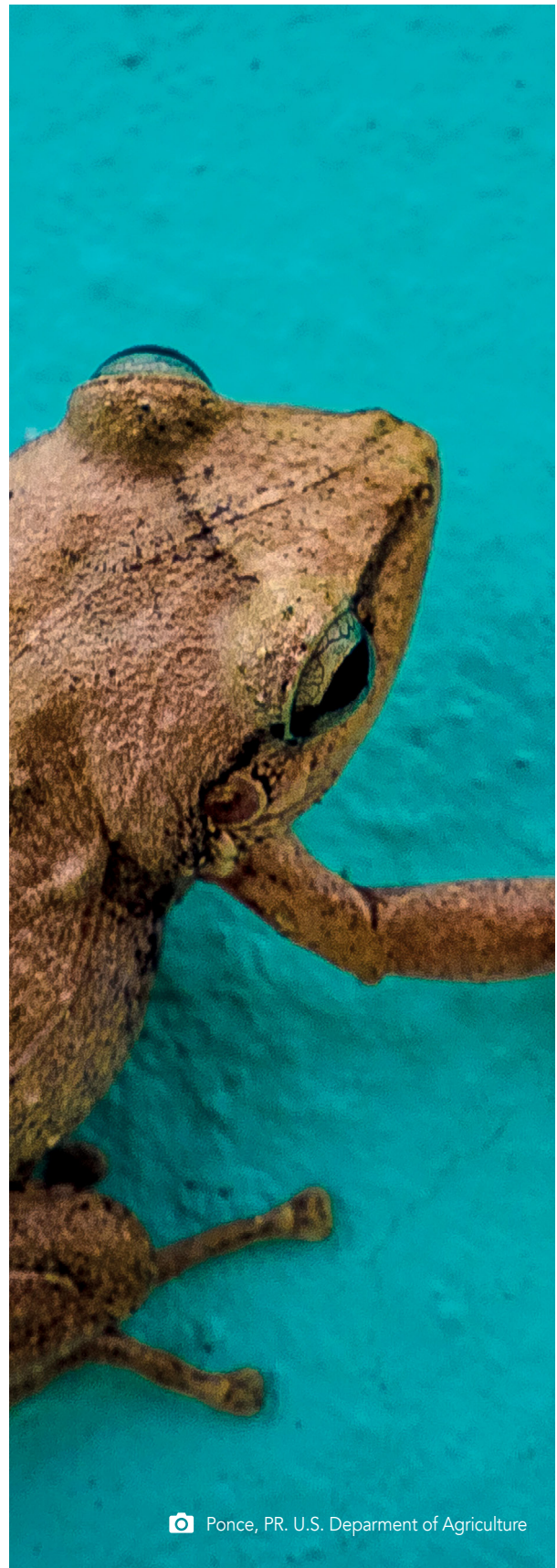
If hurricane frequency
increases, **forests will
not have enough time
to regenerate**

Post-Disaster Context

Detailed information and data on the condition of natural infrastructure and the damage caused by Hurricane María is lacking or very limited. Damage assessments are ongoing or need to be commissioned, and researchers have not published most of the results. The limited available information suggests there have been significant adverse impacts on marine and coastal resources, wildlife, and the quality of surface waters.

Wind action and storm surge caused most of the impacts of Hurricane María on the coasts. In several areas, the beaches have changed and even disappeared. Extremely intense winds left behind debris from ramps, docks, fishing villages, houses, and other buildings on beach areas. Almost all beaches lost elevation, reducing their ability to prevent coastal flooding in the future and increasing the vulnerability of coastal communities²⁸. Sand was removed from some beaches, aggravating coastal erosion²⁹. Winter Storm Riley in March 2018 further aggravated the situation. Its strong waves hit the weakened ecosystems causing more damages to beaches, coastal communities, and infrastructure³⁰.

Hurricanes Irma and María severely affected coral reefs, and the degraded quality of water caused by sedimentation and discharges of untreated wastewater aggravated the situation. In Aguadilla, the reefs ended up totally devastated. Bottom swell uprooted hundreds of colonies of brain coral and other species of massive corals. A hundred percent of the populations of several species died as a result of the hurricane or showed partial mortality. Approximately 75% of the colonies showed



 Ponce, PR. U.S. Department of Agriculture

whitening as a combined result of high temperatures and exposure to dramatic freshwater runoff during the hurricane. The whole population of Elkhorn coral (*Acropora palmata*), a threatened species, died. The also threatened population of the star coral (*Orbicella faveolata*) was either plucked and bleached or shows significant partial mortality³¹.

Untreated wastewater discharge, urban runoff, and fuel spillage affected the quality of coastal waters. Due to power outages during and after the hurricane, the operation of the 22 existing wastewater treatment plants was severely compromised resulting in tons of untreated wastewater entering streams, rivers, and the ocean. This resulted in affecting the availability of drinking water and damaging the environment. Untreated wastewater, the overflow and failure of septic tanks, and the rupture of pipelines resulted in the overflow of sanitation discharge in parts of Puerto Rico³². Other sources of contamination of freshwater resources were oils and fats, bacteria transmitted by rat urine, fecal coliform from livestock waste, and other toxic substances³³.

A significant short-term impact of the hurricane on rivers, streams, and reservoirs was the debris and sediment that entered the water bodies from the extremely heavy rains³⁴. Hundreds of landslides in the interior of the Island, as documented by the U.S. Geological Survey (USGS),³⁵ contributed significant sediment to the reservoirs.

Recent research estimates that 23 to 31 million trees may have been killed or severely damaged by Hurricane María³⁶. In El Yunque National Forest, trees were destroyed or lost more than half their height³⁷.

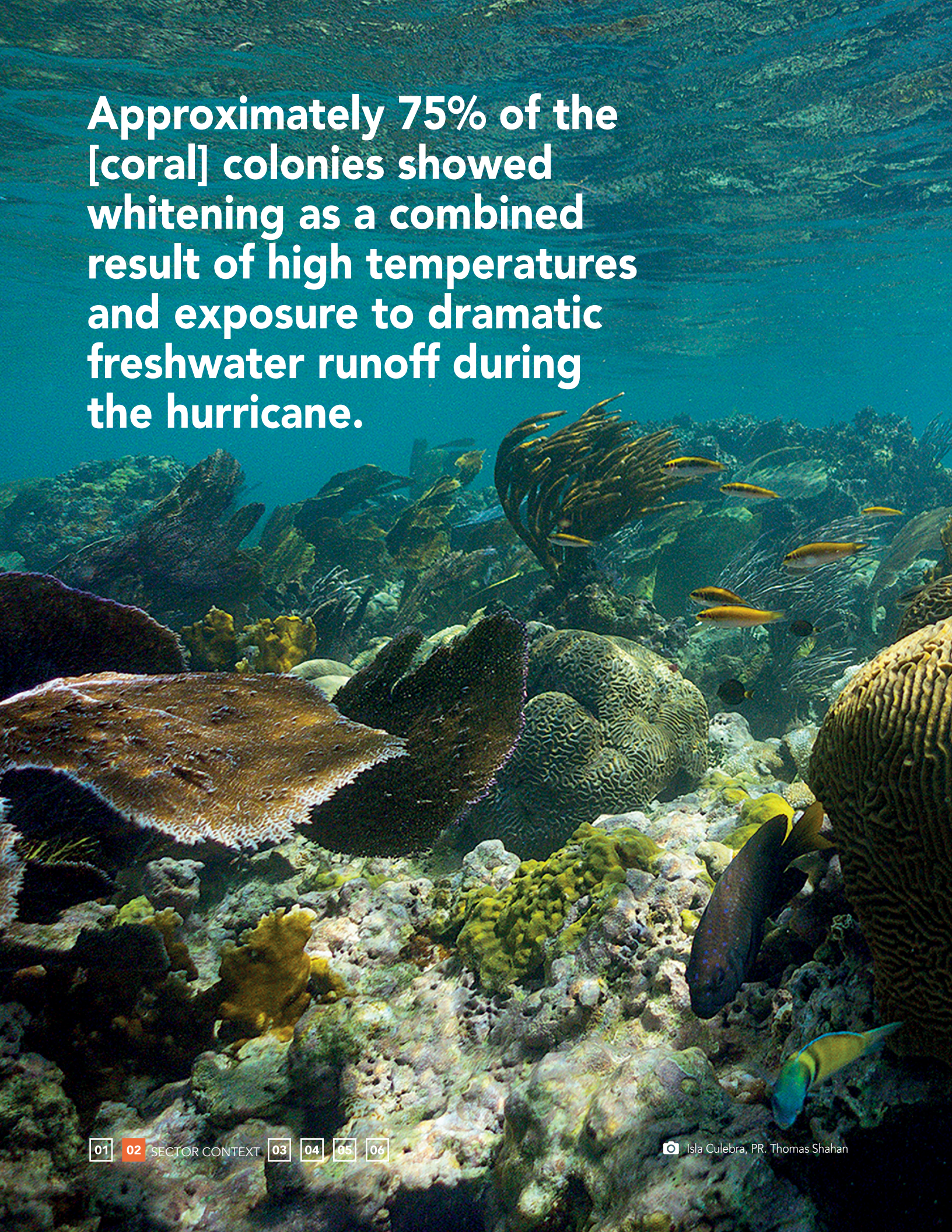
Some naturally protected areas in the mountainous interior of Puerto Rico lost almost 98% of adult trees, which has directly impacted the fauna³⁸.

One of the species of greatest concern has been the Puerto Rican parrot. This species is found only in Puerto Rico and is the only native parrot species in the United States. Before Hurricane María, conservation efforts had helped rebuild the population, and the captive and wild population combined numbered over 500. Hurricanes Irma and María, have setback the Puerto Rican Parrot Conservation Program by years. A significant portion of the native population – and some of the captive parrots – died or disappeared³⁹.

Pollinators, which are fundamental for forests and agriculture, were severely impacted, particularly the bee population. Around 80 to 90 percent of the population of bees on the Island did not survive the onslaught of Hurricane María⁴⁰. Immediately after the hurricane, approximately 50 percent of the colonies were affected by flooding or loss of nesting sites. The condition was aggravated later by the lack of flowers, pollen, and nectar⁴¹. Birds and bats populations experienced similar impacts.

Agriculture in Puerto Rico is one of the most vulnerable economic sectors to natural disasters⁴². Hurricane María affected, at least, 80% of agricultural crops, destroyed complete plantations, and dairy and poultry farms⁴³. Plantain and coffee crops suffered the most severe damage⁴⁴. The coffee plantations, when destroyed by strong winds, take several years to mature and be able to re-produce⁴⁵. The landslides in the mountainous interior of the Island eliminated many roads, which are critical for this agricultural sector⁴⁶.

Approximately 75% of the [coral] colonies showed whitening as a combined result of high temperatures and exposure to dramatic freshwater runoff during the hurricane.



Shocks and Stresses

Several shocks and stresses were identified by the Natural Infrastructure Working Group and throughout the community engagement process. These are listed below:

Key shocks include:



Hurricanes and tropical storms



Swells resulting from winter storms



Floods



Landslides and ground subsidence



Sustained high winds (not related to storms or hurricanes)



Heatwaves



Earthquakes and tsunamis



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



Epidemics and disease outbreaks (such as vector-borne diseases)

Key stresses include:



Climate change



Coastal erosion



Droughts



Loss of biodiversity



Improper use of lands



Increase in sea level rise



Poverty



Vulnerable populations, living in high-risk areas



Soil impermeabilization in urban areas



Aging of the population and social insecurity for the retired



Urban deforestation and poor access to green spaces;



Environmental degradation and environmental pollution (soil, air, and water)



Lack of diversification in water supplies



Inadequate quality of open spaces for recreation and to manage runoff



Lack of proper maintenance of the physical infrastructure, including energy and roads



Sedimentation of reservoirs



Limited capacity to develop natural based solutions



Deteriorated and aging stormwater management infrastructure

Unmet Needs

The results from the Natural Infrastructure Working Group and the community outreach and engagement process presented a set of unmet needs that can be classified under the following categories:



LIMITED OR LACK OF COMPREHENSIVE BASELINE DATA AND CONDITIONS (INVENTORY), as well as

damage assessments of natural infrastructure and ecosystems to inform restoration and rebuilding efforts. This lack of data, in turn, is preventing prioritization based on cost, benefits, and impact.



POOR WATER RESOURCES MANAGEMENT.

Unsustainable water management was identified as an unmet need by the Natural and Physical Infrastructure Working Groups and the community focus groups. Poor management, operation, and maintenance of water supply infrastructure has led to increased operating costs and is causing the depletion of water resources. Approximately 60 percent of water is lost in distribution systems, creating more pressure on the availability of water to sustain human needs and biodiversity. Puerto Rico largely depends on water extracted from reservoirs and dams, rivers (surface water), and aquifers (groundwater). Currently, wastewater recycling, including the use of gray water or rainwater harvesting, is not promoted. The Natural Infrastructure Working Group believes that finding a sustainable and long-term solution for the use of water is critical to building a more resilient Puerto Rico.



LIMITED ENFORCEMENT OF LAND USE PLANNING AND ENVIRONMENTAL REGULATIONS.

The group recognized that land use planning needs to be improved and enforced. Until now, the Puerto Rico Land Use Plan has not been effectively implemented, including other land use planning regulations which could stop construction along ecologically sensitive ecosystems and in hazard-prone areas. Planning regulations exist. However, weak land use governance systems have led to housing and infrastructure investments in hazard-prone areas. Consequently, the population at risk and the costs in the provision of services and infrastructure are high. Moreover, such governance system is causing the deterioration and loss of natural ecosystems. Population density and the use of less desirable construction sites have increased substantially during the past decades. As a result, human populations are more vulnerable to natural hazards. Landslides are common in the mountainous areas of Puerto Rico where mean annual rainfall and the frequency of intense storms are high, and hillslopes are steep⁴⁷. Each year, landslides cause extensive damage to property and occasionally result in loss of life. At present, over 49 percent of the population of Puerto Rico live in areas with moderate to highest susceptibility to landslides⁴⁸.

An aggravating factor has been the absence of demarcation of the entire Island's maritime, terrestrial zone. Land set aside for public use, natural infrastructure, and precious ecosystems is not sufficiently protected. Conventional approaches to land use planning and implementation, including participatory methods, have failed, increasing disaster risk particularly in coastal areas. Risk considerations in land use planning and enforcement has been inadequate. Therefore, development in hazard-prone areas has been legally authorized.



FOOD SECURITY AND ACCESS TO FOOD.

Puerto Rico imports approximately 85 percent of all its food, creating a potential food security threat. In Puerto Rico, there is no food security policy. There is a high dependence on imported food, and oligopolies control the shipping logistics. Also, sea routes overlap with hurricanes' paths, and the food reserves are not clearly defined⁴⁹. Climate change aggravates this vulnerability.



CONTAMINATION BY POINT AND NON-POINT SOURCES.

The leading causes of non-compliance with water quality standards are: major industrial point sources, major and minor municipal point sources, collection system failure, agriculture, confined animal feeding operations, onsite wastewater systems, landfills, debris, urban runoff/storm sewer, and surface mining⁵⁰. The Puerto Rico Aqueduct and Sewer Authority's (PRASA) wastewater treatment plants discharge approximately 232 million gallons per day (mgd) of wastewater into rivers and streams, reservoirs, and directly into the ocean. There are six regional treatment plants (Carolina, San Juan, Bayamón, Arecibo, Aguada, and Ponce) that discharge approximately 149 mgd directly into the ocean⁵¹. Other major problems are combined sewer overflows and onsite sewage treatment and disposal systems (OSTDS), commonly referred to as septic systems, common in rural communities⁵².



LACK OF A COMPREHENSIVE APPROACH TO LAND USE AND WATER MANAGEMENT.

Land and water are two essential components of the natural infrastructure that sustains Puerto Rican society. Although the use of the watershed as a planning unit has been proposed for decades, this effort has not been successful. Flood risk management/water management policy and plans (floodplain, river basin, surface water, etc.) need to be embedded within land use policy and planning processes. There is an urgent need to integrate broader flood risk policy principles into the land use planning process. The government must review existing regulations, or draft new ones, to control or restrict land development. Land use and building regulations should address appropriate uses, flood risk assessment, minimum design standards, drainage/surface water management, retrofitting, etc.



LACK OF VISION OR WILLINGNESS TO USE NATURE-BASED SOLUTIONS, AND LACK OF UNDERSTANDING OR RECOGNITION OF ECOSYSTEM VALUES AND SERVICES.

The key to sustainable development of the Island is achieving a balance between the use of natural resources for socio-economic development and conserving ecosystem services that are critical to well-being and livelihoods. Understanding how ecosystem services contribute to livelihoods, and who benefits and who loses from changes arising from development interventions is critical in Puerto Rico. Nature-based solutions (1) address hazards, such as flooding, landslides, and erosion, (2) stresses such as water quality, and (3) support economic development, tourism, and recreation. Nature-based solutions, such as green infrastructure, also protect local ecosystems. Students, teachers, and parents were especially interested in the use of ecosystem-based solutions. The inclusion of the ecosystem service values in the decision-making process was one of the unmet needs that this working group identified which could transform land use planning and the sustainable use of natural resources.



NEED TO PROMOTE THE USE OF NATURAL INFRASTRUCTURE AND GREEN JOBS⁵³ AS A FOUNDATION FOR ECONOMIC DEVELOPMENT THROUGH THE CREATION OF BUSINESSES AND AGRICULTURE, AMONG OTHERS.

Natural infrastructure was identified as an opportunity for local economic development. Feedback from the outreach and engagement activities suggests people want to participate in a meaningful way in restoration and disaster recovery efforts. They also expressed the need for support for community efforts to increase recycling and community agriculture and reduce solid/organic waste, which could become a business opportunity.

03

SECTOR
GOAL

The goal of the Natural Infrastructure sector is to improve human health and well-being, foster economic development, and reduce exposure to hazards, through the sustainable use of Puerto Rico's natural resources.

Hurricanes Irma and María caused widespread impacts on the natural resources of Puerto Rico, ranging from the devastation of the rainforest canopy, to massive production of debris, the release of chemicals and untreated sewerage into the environment, the devastation of coral reefs and seagrasses, and the severe erosion and destruction of the coastline and associated biomes. Damage to beaches, dunes, and bluffs that normally provide a natural barrier to coastal flooding was severe, significantly increasing the risks of future damages in those areas. The devastation of the rainforest and the existence of storm debris impacted the landscape and biological corridors of conservation and connectivity, as well as habitats for endangered species. Up to now, we do not know the total damage and its medium- to long-term impact on Puerto Rico's environment and natural resources and it might take months or even years to evaluate, mitigate, and repair fully. Puerto Rico will have to develop a comprehensive

strategy to assess short, medium, and long-term impacts of the storms plus monitor impacts over time and track progress related to restoration efforts. The restoration of damaged ecosystems will take a long time and will require a long-term vision, as well as funding allocations. By making the conservation and the sustainable use of natural resources a constitutional mandate, the long-term objective has been anchored in public policy. The Constitution establishes “the conservation, development, and use of the Commonwealth’s natural resources in the most effective possible manner for the general welfare of the community” (Article VI, Section 19.)⁵⁴. This strengthens the legitimacy and provides an opportunity to advance programs and policies that protect natural resources, promote the use of nature-based or green infrastructure solutions, and improve agricultural practices and output to improve food security and support the local economy in the face of a changing climate.



A resilient natural infrastructure system will provide Puerto Rico healthy and strong ecosystems and engage present and future generations of Puerto Ricans as stewards and beneficiaries of the ecosystems' goods and services.



📷 Lajas, PR. Angel Xavier Viera-Vargas

A resilient natural infrastructure system will provide Puerto Rico healthy and strong ecosystems and engage present and future generations of Puerto Ricans as stewards and beneficiaries of the ecosystems' goods and services. We describe below in more detail strategic objectives and actions we proposed to achieve this vision. They are aligned with and will support the Commonwealth's constitutional mandate. Moreover, these actions are based on the belief that education and meaningful citizen participation are necessary to achieve this vision and should permeate the recovery process.

The concept of sustainability is critical not only to achieve the main goal of the natural infrastructure

sector but also to promote more resilient and equitable societies in Puerto Rico and abroad. As Public Law 267-2004 enacts, sustainable development in Puerto Rico must aim at achieving a process "... where its economic goals, social and environmental issues are unified within the context of sustainable development and its condition of a small island state."⁵⁵ Following the international principles of sustainable development⁵⁶, ongoing recovery and reconstruction efforts in Puerto Rico must continue to promote a process where development actions can make use of existing natural resources without compromising access and rights of use of such assets for future generations.



Short term

In the short-term, Puerto Rico will have to focus on completing a comprehensive damage assessment of its entire coastline and its precious ecosystems. Rainforest, mangroves, watersheds, and damaged reefs need particular attention. The impact of the hurricanes has alerted the Island to the necessity of working with local communities to achieve a well-used, managed, connected, and expanding network of nature-based solutions which can provide a wealth of benefits for people, places, and nature itself. Nature-based solutions support healthy lifestyles, ecosystems, and thriving communities, as well as provide ongoing access to the outdoors and enhance landscape character, biodiversity, and built heritage. The destruction caused by the hurricanes and the rebuilding effort create a vast potential to incorporate nature-based solutions in local planning, zoning, regulations, and building projects to help reduce their exposure to flood and erosion impacts. As such, there is an opportunity to inform and start developing a policy framework that supports creating an enabling environment to promote nature-based solutions for recovery, reconstruction, and beyond.



Medium term

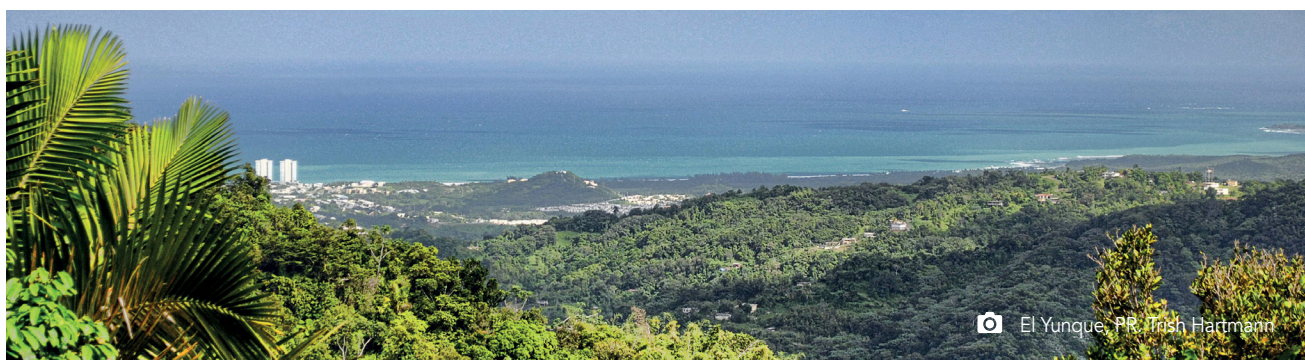
In the medium term, Puerto Rico will focus on identifying and implementing projects, based on the results of the damage assessment, which begin the process of restoring the Island's natural habitat. These initiatives, besides others, will involve the protection and restoration of watersheds, replanting and reforestation, the removal of invasive species, enhancement of wastewater treatment plants, and restoration of agriculture to enhance the environment and strengthen the economy. Comprehensive guidance will be developed to promote green infrastructure to improve resilience in the built environment. A robust regulatory framework will be required to guide restoration efforts and the long-term development of the Island. At the Island level, this may refer to interventions that focus on natural areas that provide habitat, food, flood protection, cleaner air, and cleaner water. At the smaller scale of a neighborhood or site, the focus will be on improving stormwater management using green infrastructure that mimics nature by soaking up and storing water and reducing the vulnerabilities to flooding. At the same time, this strategy will allow for developing green spaces that mitigate the urban heat island effect by providing shade and space for recreation. The development of green infrastructure will encourage a more sustainable and resource-efficient development process to achieve the Island's long-term objective to rehabilitate, protect, and improve natural ecosystems to provide essential services. The use of green infrastructure will act as a catalyst to economic growth by attracting inward investments and generating employment, reducing environmental costs, and providing health benefits, amongst others. Investing in green infrastructure will contribute to the recovery of the economy by fostering innovative approaches and creating green businesses.



Medium to long term

Nature-based solutions will play a major role in enhancing coastal resilience in the medium to long-term. Puerto Rico needs to develop its coastlines not only to address the impacts of the last hurricane season but also for the rising sea-levels, the potential changes to storm climates and the increasing human development in the years to come so it can withstand and rebound after such hazardous impacts. To achieve coastal resilience, Puerto Rico must be prepared for future extreme events and adapt management practices to the changing environmental and manmade conditions expected over the coming centuries. This preparedness will require comprehensive shoreline management and planning policies, while at the same time it will improve the predictive capability to forecast events and future state changes within Puerto Rico's coastal systems. Puerto Rico needs to identify flood and erosion risk management solutions that incorporate the natural habitat to sustain healthy coastal ecosystems. These solutions entail the development of resilient management strategies through more precise identification of vulnerabilities and a better understanding of human and nature-driven impacts within the coastal systems. Coastal wetlands and mangroves are vulnerable to sea level rise while, at the same time, critical habitat for commercial and recreational fish and invertebrate species. Loss of these ecosystems through sea level rise could pose a real threat to Puerto Rico's coastal economy and water quality. Incorporating planning for sea level rise in the restoration efforts will preserve inundated lands and allow coastal wetlands to migrate inland and maintain their essential functions for the community.

Also, Puerto Rico's coastal communities must plan since more citizens, and their homes and businesses are in the path of increasingly dangerous and costly storm conditions. The decisions that were made in the past to develop the shoreline, and today to build back after the hurricanes, will dictate the Island's ability to bounce back from future storm events. Developing an understanding of where and how communities are vulnerable to losses due to coastal hazards and implementing planning and development practices to compensate for these vulnerabilities will ultimately result in lives and dollars saved, and stronger communities for the future.



04

OPPORTUNITY ACTIONS

Action Sheet Guideline

Action number

Action title

A1

Develop a public policy to promote the use of nature-based solutions in the reconstruction process of Puerto Rico.

Description

In the short-term, this action will consist of the development of a public policy that informs policy- and decision-makers, local permitting agencies, and the public on how nature-based solutions, such as green infrastructure, should be incorporated in the reconstruction process. This public policy framework will strengthen the capacity of municipalities, Commonwealth entities, developers, and citizens to consider alternatives to gray infrastructure and base decisions on economic and resilience values. In the long-term, this initiative will raise awareness among all interested parties about natural infrastructure as a viable solution.

Action steps include:

1. Revise and propose amendments to the existing public policy framework, based on a comprehensive gap analysis (e.g. Joint Permits Regulation).
2. Define a decision-making framework and cost-benefit analysis tools to consider monetary benefits and costs to address the trade-offs between immediate economic benefits and future benefits from social and ecosystem services.
3. Develop a monitoring system to evaluate the policy's efficiency and effectiveness.
4. Identify a priority pilot project to fast-track and demonstrate the value of nature-based solutions in building resilience, creating public awareness, and enhancing visibility.
5. Develop at least two pilot projects that:
 - Develop wetlands for water and wastewater treatment to compensate or substitute the traditional wastewater treatment infrastructure;
 - Enhance lands to improve biodiversity, restore natural functions (i.e. groundwater replenishment), increase or secure land productivity, and enhance well-being;
 - Restore wetlands and living shorelines to augment and strengthen gray infrastructure, reduce flood risk, and protect shorelines from erosion caused by waves;
 - Develop multifunctional public green spaces to reduce heat island²³ effects, flooding, and climate change stresses, while improving life quality;
 - Enhance and/or generate innovative reefs to reduce erosion and coastal surge.
6. Develop a financing or incentive mechanism (monetary or non-monetary) to promote the use of nature-based solutions during reconstruction.

Description: The action description will address expected results and questions such as: What? How?

Potential Lead

Central Recovery and Reconstruction Office of Puerto Rico

Potential Co-leads

Puerto Rico Planning Board; Department of Natural and Environmental Resources; Commonwealth Legislature

Potential Funding Sources

USEPA Environmental Education Grants Program; CDGB-DR and FEMA Hazard Mitigation.

Unmet Needs



Crosscutting Benefits



Timeframe

Short-term (1-2 years)
Long-term (5+ years)

Timeframe: Short, medium, and/or long term

Potential Lead:

Lead organization responsible for execution of action

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

Potential Funding Sources:

Federal, local, and philanthropic resources

Unmet Needs:

- Limited or lack of comprehensive baseline data and conditions (inventory)
- Limited enforcement of land use planning and environmental regulations
- Poor water resources management
- Contamination by point and non-point sources
- Lack of a comprehensive approach to land use and water management
- Food security and access to food
- Lack of vision or willingness to use nature-based solutions, and lack of understanding or recognition of ecosystem values and services

Need to promote the use of natural infrastructure and green jobs as a foundation for economic development through the creation of businesses and agriculture, among others

Crosscutting Benefits:

- Housing
- Energy
- Physical Infrastructure
- Health, Education & Social Services
- Economic Development
- Natural Infrastructure

Goal and Actions

Improve human health and well-being, foster economic development, and reduce exposure to hazards, through the sustainable use of Puerto Rico's natural resources.

A1

Develop comprehensive watershed plans using integrated water resources management to promote the sustainable use of water resources and maximize the resultant economic and social well-being.

A2

Effectively implement the Puerto Rico Land Use Plan, following a risk-based framework, to achieve social well-being, economic development, and protect critical ecosystems.

A3

Adopt a post-disaster framework to delimitate the coastal maritime zone and effectively define land uses, development codes, and protect coastal ecosystems adapted to current and future conditions.

A4

Develop a public policy to promote the use of nature-based solutions in the reconstruction process of Puerto Rico.

A5

Enforce Open Space determinations with programs/guidelines for the dedication of lands to the creation of parks, green infrastructure projects, land conservation, or other adequate uses.

A6

Develop a coastal ecosystem restoration and enhancement program.

A7

Develop key policies, within and beyond the Common Agricultural Policy, to foster agroecology.

A8 | Develop green infrastructure design guidelines for urban areas, and identify and implement pilot projects.

A9 | Develop an integrated treatment program for wastewater and stormwater run-off to reduce sewage pollution affecting freshwater, coastal, and marine resources.

A10 | Re-evaluate the design of proposed flood control projects to integrate resilience criteria and nature-based solutions.

A11 | Develop a training and capacity-building program to promote key green businesses in the recovery process.

A12 | Develop a comprehensive assessment of natural resources to identify priority areas for intervention and conservation.

A13 | Develop an integrated recycling program to promote the use of resourceful construction materials and create green jobs.

A14 | Develop a program to promote sustainable agricultural practices.

A15 | Develop an emergency preparedness and response plan for Puerto Rico's natural resources.

A16 | Create community garden programs in rural and urban areas.

Develop comprehensive watershed plans using integrated water resources management to promote the sustainable use of water resources and maximize the resultant economic and social well-being.

Description

A watershed plan will identify protection and sustainable development practices and enhance access to sustainable water resources in Puerto Rico. The impacts of Hurricanes Irma and María, along with the 2014 - 2016 drought, highlighted the need for improved watershed management tools to protect critical freshwater resources and wildlife, reduce the risk to life and property, and facilitate economic development opportunities.

Since 2016, water management policies in Puerto Rico have used watersheds as the planning unit for water resource management. However, limited efforts have been made to prepare integrated planning tools and promote sustainable practices along watersheds. Watershed plans require an all-encompassing approach that includes specific land uses, ecosystems enhancement projects, use of sustainable agricultural practices, and sustainable and comprehensive water resources management. In the short term, it is important to focus on the watersheds that have been most impacted.

Activities will entail:

- Adopting best land use practices that consider multiple hazard assessments.
- Using best management practices to address erosion and sedimentation, including addressing unpaved roads.
- Reforestation.
- Relocation of structures in high hazard areas.
- Addressing farmers' needs and implementing reduction of water usage.
- Reuse and collection of rainwater alternative methods.
- Ensuring equal access for all users.
- Bringing the greatest benefit to the greatest number of users possible.

Due to Puerto Rico's ridge-to-reef topography, effective watershed management will result in more resilient coastal and marine ecosystems, as well as greater protection of freshwater resources.

Potential Lead

Puerto Rico Department of Natural and Environmental Resources

Potential Co-leads

PRPB; PMO; USDA; PRASA; EQB; Municipalities; NRCS; EDA; EPA; NGOs

Potential Funding Sources

DNER: Water Fund; NRCS: EQIP; EPA 319 grant program and Clean Water State Revolving Funds; Innovative financial bonds

Unmet Needs



Crosscutting Benefits



Timeframe



Long term

Effectively implement the Puerto Rico Land Use Plan, following a risk-based framework, to achieve social well-being, economic development, and protect critical ecosystems.

Description

The government approved the current Puerto Rico Land Use Plan in 2015 and used FEMA Flood Insurance Rate Maps (FIRM) to identify flood-prone areas, develop related policies, and assign land use classifications. Hurricane María demonstrated that areas susceptible to flooding are more extensive than anticipated and include several urban centers and multiple coastal areas. FEMA recently developed preliminary advisory flood maps where areas that were flooded during Hurricane María have been identified.

The Puerto Rico Land Use Plan should be revised to include this updated information and refine policies accordingly. A revised plan will offer greater certainty when developing reconstruction projects, and it will help reduce their vulnerability to future floods. Also, the revised land use plan should include recently collected data regarding erosion, landslides, and sea level rise. This information will be the basis for the establishment of coastal setbacks, refinement of zoning codes, and additional adaptation strategies in land use planning to address multiple hazards.

New Orleans’ response to Hurricane Katrina, in this regard, provides a valuable lesson. After Hurricane Katrina, the state was not proactive in developing guidelines and zoning codes to direct reconstruction investment. This lack of an appropriate response hampered the effective implementation of other economic and social development programs and increased restoration costs⁵⁷.

This action and the rigorous implementation of the plan are a priority for guiding reconstruction and increasing resilience. Sensitizing and informing about land use planning is vital. Making respective information available is also essential to increase transparency and empower citizens. Additionally, this action will reduce property damage in risk areas, protect critical ecosystems, and promote transparency and good governance.

Potential Lead

Puerto Rico Planning Board

Potential Co-leads

DNER; PRDPS; PRPS

Potential Funding Sources

CDBG-DR

Unmet Needs



Crosscutting Benefits



Timeframe



Short term

Adopt a post-disaster framework to delimitate the coastal maritime zone and effectively define land uses, development codes, and protect coastal ecosystems adapted to current and future conditions.

Description

This action intends to facilitate the implementation of post-disaster recovery activities, along coastal zones, that can reinforce the use of natural assets and best land use management practices to safeguard life and property, particularly in areas adversely impacted from recent extreme events. The recent hurricanes uncovered once more the vulnerability of many coastal communities and infrastructure systems located within coastal zones. Erosion rates and sea level rise are also two critical stresses that heighten vulnerability along these zones.

An important first step would be to establish a clear demarcation of the maritime-terrestrial zone. Based on this exercise, appropriate bodies can undertake necessary actions to reduce risk in most vulnerable areas identified. These activities can build on the DNER Coastal Zone Management Program, which developed a study to incorporate resilience and adaptation strategies into land use planning. This program includes specific recommendations on how to increase setbacks using erosion rates and coastal inundation - including sea level rise. The DNER should update this study by incorporating data from the impacts of Hurricanes Irma and María, along with recent winter sea swells. Another important aspect of this framework will be increased coordination among the DNER, the Puerto Rico Planning Board, and coastal municipalities, enabling these entities to collaboratively and coherently focus their actions on identifying and implementing adaptation strategies to reduce risk along vulnerable coastal zone lands.

One specific activity could be the establishment of rolling easements, an approach that allows wetlands, beaches, and barrier islands to migrate inland as sea levels rise. While allowing beaches and wetlands to migrate inland, these easements continue to protect the communities they abut as buildings and hard infrastructure is removed from these paths. Other approaches can incorporate a combination of actions mixing natural and gray infrastructure following best management practices on vulnerable coastal zones. This action will benefit coastal communities and facilitate future investment by implementing a risk reduction approach. The implementation of best management practices for land use along coastal zones, including the implementation of coastal setbacks, will protect life, property, and critical ecosystems, and it can reduce conflicts over land use. It will improve public access to the coasts and enhance the aesthetics of the shoreline, an important asset for Puerto Rico as a tourist destination.

Potential Lead

Puerto Rico Department of Natural and Environmental Resources

Potential Co-leads

PRPB; Coastal municipalities; COR3

Potential Funding Sources

CDBG- DR; FEMA

Unmet Needs



Crosscutting Benefits



Timeframe



Medium term

Develop a public policy to promote the use of nature-based solutions in the reconstruction process of Puerto Rico.

Description

In the short-term, this action will consist in the development of a public policy that informs policy- and decision-makers, local permitting agencies, and the public on how nature-based solutions, such as green infrastructure, should be incorporated in the reconstruction process. This public policy framework will strengthen the capacity of municipalities, Commonwealth entities, developers, and citizens to consider alternatives to gray infrastructure and base decisions on economic and resilience values. In the long-term, this initiative will raise awareness among all interested parties about natural infrastructure as a viable solution.

Action steps include:

1. Revise and propose amendments to the existing public policy framework, based on a comprehensive gap analysis (e.g., Joint Permits Regulation).
2. Define a decision-making framework and cost-benefit analysis tools to consider monetary benefits and costs to address the trade-offs between immediate economic benefits and future benefits from social and ecosystem services.
3. Develop a monitoring system to evaluate the policy's efficiency and effectiveness.
4. Identify a priority pilot project to fast-track and demonstrate the value of nature-based solutions in building resilience, creating public awareness, and enhancing visibility.
5. Develop at least two pilot projects that:
 - Develop wetlands for water and wastewater treatment to compensate or substitute the traditional wastewater treatment infrastructure.
 - Condition soils to improve biodiversity, restore natural functions (i.e., groundwater replenishment), increase or secure land productivity, and enhance well-being.
 - Restore wetlands and living shorelines to augment and strengthen gray infrastructure, reduce flood risk, and protect shorelines from erosion caused by waves.
 - Develop multifunctional public green spaces to reduce heat island⁵⁸ effects, flooding, and climate change stresses, while improving life quality.
 - Enhance and generate innovative reefs to minimize erosion and coastal surge.
6. Develop a financing or incentive mechanism (monetary or non-monetary) to promote the use of nature-based solutions during reconstruction.

Potential Lead

Puerto Rico Central Office of Recovery, Reconstruction, and Resilience

Potential Co-leads

PRPB; DNER; Puerto Rico Legislature

Potential Funding Sources

EPA Environmental Education Grants Program; CDBG-DR; HMGP

Unmet Needs



Crosscutting Benefits



Timeframe



Medium and long term

Enforce open space determinations with programs/guidelines for the dedication of lands to the creation of parks, green infrastructure projects, land conservation, or other adequate uses.

Description

A program and guidelines should be developed to support the Commonwealth and municipal governments to effectively promote the acquisition of open spaces from private lands and properties in high hazard areas. Under the FEMA’s Hazard Mitigation Grant Program, open spaces are areas perpetually dedicated to the conservation of natural floodplain functions and restricted from any use or development that interferes with that purpose.

The proposed programs and guidelines will create more resilient communities and enhance communities’ aesthetics. They will also reduce spending on construction, maintenance of infrastructure for flood control, and National Flood Insurance Program (NFIP) payments for insurance claims. Overall, this action will reduce federal, Commonwealth, and municipal spending on emergency response.

This program will define actions to demolish existing structures and maintain lands as open spaces for permanent public use and multi-benefits. Therefore, besides reducing the number of individuals living in high hazard areas, these guidelines will define land use requirements, establish processes for place-based projects, and promote multifunctional projects. Projects might create multi-function recreational parks, urban forests, and edible urban gardens, as well as restore dunes and wetlands and improve wildlife habitats while providing economic and social benefits. Projects might also include improvement of stormwater management with flood storage/overflow areas. Additionally, the program will define requisites for the establishment of partnerships and collaborations with NGOs in order to develop and administer the determined open spaces.

In Puerto Rico, high hazard areas impacted by Hurricane María, as well as abandoned and deteriorated structures, should be prioritized. Structures and properties that have experienced repetitive losses based on the National Flood Insurance Program (NFIP) should also be highlighted. The Puerto Rico Planning Board should maintain all the determined open spaces in overlay districts, as well as include coordination requirements and monitoring systems in association with non-profit organizations.

Potential Lead

Puerto Rico Department of Housing

Potential Co-leads

HUD; PRPB; PMO; GAR; DNER; PRDHo; Municipalities; NGOs

Potential Funding Sources

HMGP; CDBG-DR; HMGP; Repetitive Flood Claims Grant; EWP-FPE

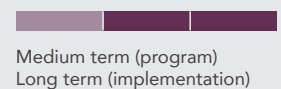
Unmet Needs



Crosscutting Benefits



Timeframe



Description

The purpose of this action is to design a coastal ecosystem program around community interventions to reduce hazard exposure and impacts from flooding, strengthen and protect wildlife habitat, increase connectivity and landscape, improve fishing, and economic activity. This program should promote ownership and effective stewardship of ecosystems. Based on a comprehensive assessment of the coastal ecosystem, priority sites and partners will be identified to develop innovative solutions with a participatory approach, with an active (impact) monitoring.

Proposed intervention areas include the enhancement or creation of:

- Wetlands to (1) reduce the impacts of storms⁵⁹ and limit erosion, (2) provide habitat for fish and bird species, (3) create opportunities for outdoor and tourism activities, (4) reduce flood risks and (5) help with temperature regulation.
- Coral reefs and seagrass: In short-term, integrate National Oceanic and Atmospheric Administration (NOAA) damage assessment and restoring coral fragments along the eastern coast. The valuable ecosystems across the Island need a medium to long-term restoration initiative to restore and maintain them. These actions include establishing nurseries and coral farms, in collaboration with community-based groups, to do monitoring and restoration work.
- Dunes: Dunes should be protected and enhanced to protect the coast from flooding and storm surges, provide habitat for shorebirds, and support tourism. The municipality of Isabela, led by the academy, with volunteers and federal and Commonwealth support, implemented a successful project⁶⁰.
- Beaches: There could be a beach restoration pilot project in Parcelas Suárez in Loíza and Rincón. The pilot project will require:
 - Debris removal in private and public domain lands.
 - Demolition of severely impacted beach-front properties and the dedication of these areas as open spaces.
 - The implementation of nature-based solutions, and, if feasible.
 - Beach nourishment and the collocation of artificial coral reefs to reduce wave energy.

Potential Lead

Puerto Rico Department of Natural and Environmental Resources

Potential Co-leads

NOAA; NRCS; NGOs; Communities

Potential Funding Sources

DNER (Under Section 309 of the Coastal Zone Management Act); USFWS National Coastal Wetlands Conservation Grants; USFWS Coastal Program; Competitive funding sources (NOAA Coastal Resilience Grants); FEMA recovery and mitigations grants

Unmet Needs



Crosscutting Benefits



Timeframe

Medium term



Develop key policies, within and beyond the Common Agricultural Policy, to foster agroecology.

Description

The agricultural policy in Puerto Rico (Puerto Rico Agricultural Tax Incentives Act, Law No. 225 of 1995, as amended) does not consider agroecological practices, resulting in few or no incentives for these farmers. On the contrary, the government has incentivized monoculture and similar agriculture-related research activities, some of which are contaminating and depleting aquifers and degrading wetlands and natural habitats. Putting agroecological technologies into practice requires technological innovations, agriculture policy changes, socio-economic changes but mostly a deeper understanding of the complex long-term interactions among resources, people, and their environment.

The government should revise and strengthen existing public policy to encourage the protection of natural ecosystems and the sustainable use of natural resources. Policy- and decision-makers, local professional associations of agronomists, and farmers need to be sensitized about the resilience benefits of farming that centers on the best use of nature's goods and services. Agroecology applies ecology to the design of farming systems, uses a whole-systems approach to farming and food systems, and links ecology, culture, economics, and society to create healthy environments, food production, and communities. It centers around agricultural practices that: use renewable, on-farm resources wherever possible, minimize the production of pollutants, conserve soils, water, energy, and genetic resources, adjust to local environments, empower local people, and value long-term benefits.

For decades, agroecologists have contended that a key strategy in designing sustainable agriculture is to reincorporate diversity into the agricultural fields and surrounding landscapes to manage it more effectively. Polycultures exhibit greater yield stability and fewer declines in productivity during a drought than monocultures⁶¹. In the context of a changing climate and growing concerns for more sustainable and healthy food systems, agroecology is gaining momentum as a scientific discipline, sustainable farming approach, and social movement.

We can measure the success of this strategic action by the amount of land and the number of farmers using agroecological practices. In the short term, this action will benefit agroecological farmers, and in the longer term, it will expand to communities throughout Puerto Rico.

Potential Lead

Puerto Rico Department of Agriculture

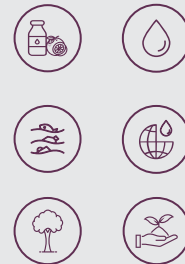
Potential Co-leads

Organización Boricúa and USDA

Potential Funding Sources

USEPA Environmental Education Grants Program

Unmet Needs



Crosscutting Benefits



Timeframe



Long term

Develop green infrastructure design guidelines for urban areas, and identify and implement pilot projects.

Description

This action pursues the development of green infrastructure design guidelines and recommendations to facilitate a more sustainable and resource-efficient post-disaster development process. Green infrastructure benefits nature and people, and it aims to enhance nature’s ability to deliver multiple services and valuable ecosystem goods. In turn, it will: (1) foster a better quality of life and human well-being, (2) improve biodiversity by reconnecting isolated nature areas and increasing the mobility of wildlife across the wider landscape, (3) protect the Island against climate change and other environmental disasters, (4) encourage a more integrated approach to development that ensures an efficient use of the Island’s limited space, and (5) act as a catalyst for economic growth by attracting investments and generating employment.

Investing in green infrastructure may contribute to the recovery of Puerto Rico’s economy by creating a market for the development of green businesses⁶².

The proposed guidelines serve these main purposes to:

- Be used in the reconstruction process under the Community Development Block Grant Disaster Recovery Funds (CDBG-DR⁶³).
- Support municipalities to comply with the stormwater management plans and regulations.
- Design a cost-benefit analysis tool for green infrastructure adapted to Puerto Rico.
- Define monitoring criteria to characterize green infrastructure benefits for future projects and regulations.
- Instruct the use of native and endemic species.

Example projects include multipurpose parks and open spaces that address flooding and recreational needs, localized flood reduction projects, projects for stabilizing soils (including vegetative buffer filter strips), and the implementation of permeable pavements, cisterns, green roofs, and green streets, among other opportunities.

After completing the guidelines, pilot projects could help test solutions in the different watersheds. In the Río Piedras watershed, a pilot project could address impacts from urban flooding and heat island effect. The Caguas-Juncos aquifer watershed could benefit from promoting infiltration in this highly urbanized valley. A pilot project in the south coast aquifer watershed would encourage groundwater recharge and improve water quality.

Potential Lead

Puerto Rico Planning Board

Potential Co-leads

PMO; EQB; DNER; EPA; USFS; CAAPPR

Potential Funding Sources

EPA Clean Water Act Nonpoint Source Grant (Section 319 Grants); CDBG-DR; HMG

Unmet Needs



Crosscutting Benefits



Timeframe



Medium term

Develop an integrated treatment program for wastewater and stormwater run-off to reduce sewage pollution affecting freshwater, coastal, and marine resources.

Description

An integrated treatment program will develop a holistic approach to stormwater and wastewater management to improve the quality of effluent and support wetlands and coral reef restoration efforts. This action will reduce the amount of untreated wastewater entering the Island’s water bodies, thereby improving water quality.

Combined sewer overflows and onsite sewage treatment and disposal systems are affecting marine life. Existing wastewater treatment plants that discharge directly into the ocean should be upgraded from primary to tertiary treatment, allowing for the removal of remaining inorganic compounds and substances before effluent is reused, recycled, or discharged into the environment.

Water quality monitoring systems need to be reviewed and improved. The improvement of waste and stormwater treatment will reduce anthropogenic stresses to marine ecosystems, consequently improving their ability to cope with increases in sea surface temperature, acidification, hurricanes and storms, and sea level rise. Additionally, it will enhance sanitation service provisions.

The potential use of innovative wastewater treatment solutions for coastal communities that are not currently connected to the public sewerage network should be assessed, such as natural biogeochemical processes. For example, wetlands allow for low energy and high-quality wastewater treatment that results in environmental enhancement by maintaining, creating, and restoring wetland hydrology and habitat⁶⁴.

Flood control pump stations and related infrastructure also need to be improved and equipped with diversified backup power sources. A pilot project could be developed for the Puerto Rico Department of Natural and Environmental Resource’s (DNER) Baldorioty Water Pump Station and its service area. This pilot could include a green infrastructure project. Capacity building measures for selected stakeholders, including the Puerto Rico Aqueduct and Sewers Authority (PRASA), DNER, municipalities, and communities need to be designed and implemented. The training should focus on project preparation, management, and efficient operations of newly acquired sewerage systems.

Potential Lead

Puerto Rico Aqueduct and Sewer Authority

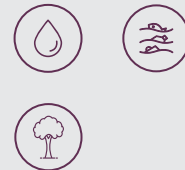
Potential Co-leads

EQB; DNER; PRPB; Municipalities; EPA; FEMA; AIDIS

Potential Funding Sources

EPA Clean Water State Revolving Fund; FEMA recovery funds

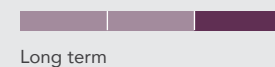
Unmet Needs



Crosscutting Benefits



Timeframe



Re-evaluate the design of proposed flood control projects to integrate resilience criteria and nature-based solutions.

Description

Some of the flood control projects proposed by the U.S. Army Corps of Engineers (USACE) in Puerto Rico involve either high-velocity concrete channels or levees. These flood control approaches⁶⁵ have not always proven to be effective and tend to have high environmental, social, and economic costs. Levees and floodwalls decrease the risk of small floods but increase the risks of big floods by narrowing the channels of rivers, forcing the water to rise higher and flow faster. Besides, the presence of levees and the availability of flood insurance create a false sense of security, encouraging the public and private sectors, as well as individuals, to develop areas that were once floodplains.

There is a need to inventory and re-evaluate the design of proposed flood control projects, considering resilience values and benefits, and promote the use of nature-based or green infrastructure solutions. As the local sponsor of flood control projects for riverine flood mitigation, the DNER should prioritize projects that are more likely to be considered for redesign. This prioritization should be presented and discussed with the USACE.

Possible flood control pilot projects would include Río Piedras and Río La Plata. In the case of the Puerto Nuevo Flood Control Project for Río Piedras, this initiative is complicated with the need to avoid impacts on natural and historic resources.

This action will promote flood control measures and mitigate flood impacts while improving water quality and enhancing wildlife habitat. It is an example of integrated management. The action will focus on achieving economic benefits, such as reducing flood damage cost and maintenance, and increase tourism while protecting natural and cultural sites.

Potential Lead

Puerto Rico Department of Natural and Environmental Resources

Potential Co-leads

Municipalities of Aguadilla and Toa Baja; USACE; Para La Naturaleza

Potential Funding Sources

Congressional funds through the Water Resources Development Act

Unmet Needs



Crosscutting Benefits



Timeframe



Long term

Develop a training and capacity-building program to promote key green businesses in the recovery process.

Description

A training and capacity building program for nature-based solutions, agriculture, and other green jobs could be developed using Puerto Rico recovery funds allocated to create local jobs. This action can be implemented by municipalities with 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.

Business opportunities that have been identified include:

- Recycling and composting businesses.
- Nurseries to propagate endemic and native plants.
- Installation and maintenance businesses focusing on renewable energy systems, wastewater reuse, rainwater harvesting, and green roof installations.
- Arborists to adequately integrate trees in urban areas and maintain electrical grids.

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, manage organic residuals, and green infrastructure solutions

Potential Lead

Office for the Community and Socioeconomic Development of Puerto Rico

Potential Co-leads

DEDC; PRIDCO; DNER; Municipalities; HUD; EDA

Potential Funding Sources

CDBG-DR for a Small Business Loan or Grant Program; Low- or no-cost loans can be provided to small businesses that have been impacted by the disaster or are part of a targeted industry for future growth

Unmet Needs



Crosscutting Benefits



Timeframe



Medium term

Develop a comprehensive assessment of natural resources to identify priority areas for intervention and conservation.

Description

A comprehensive assessment of natural infrastructure conditions will provide baseline information to identify restoration needs, prioritize areas of intervention, and select appropriate resources management measures. We envision this effort as a continuous and long-term assessment that builds on pre- and post-María assessments, technology, and citizen participation.

Action steps include:

1. Coordinate and harmonize assessment efforts with relevant stakeholders, for example, assessments conducted as part of the FEMA Natural and Cultural Resource Recovery Support Function.
2. Conduct ground and aerial rapid damage assessments based on the latest technology available to prepare visualization tools and maps to compare the situation 'before' and 'after' the hurricanes and other weather-related events.
3. Identify the areas most affected and recommend potential actions.
4. Create a centralized digital and georeferenced repository with open access and combine it with the Puerto Rico Planning Board's Puerto Rico Interactive Map.
5. Design a viable ongoing monitoring system program to provide valuable information and develop future risk reduction, resilience strategies, and identify financial stability.

Impact monitoring activities should involve volunteers and non-governmental organizations. Also, the viability of the program should be considered in collaboration with independent entities that will sustain an adequate platform to manage data.

The coastal area is a priority. The information gathered will enable planners, government officials, and communities to develop risk reduction, restoration, and coastal resilience strategies, and identify related interventions to mitigate future impacts and reduce social, economic, and ecological vulnerability. Also, baseline data will allow for measuring the effectiveness of efforts to reduce disaster or climate change impacts in the future. Accurate assessments will help decision makers target areas that need habitat improvements and increase stewardship.

Potential Lead

Puerto Rico Department of Natural and Environmental Resources

Potential Co-leads

PRPB; GAR; PREMA; PRPA; USFWS; NOAA; NGOs; Volunteers

Potential Funding Sources

DNER (Under Section 309 of the Coastal Zone Management Act); USFWS National Coastal Wetlands Conservation Grants; NOAA Coastal Resilience Grants; National Science Foundation; Other NGOs (Citizen Science Programs)

Unmet Needs



Crosscutting Benefits



Timeframe



Short term and medium term



Develop an integrated recycling program to promote the use of resourceful construction materials and create green jobs.

Description

Act 70 of September 18, 1992, Law for the Reduction and Recycling of Solid Waste in Puerto Rico, establishes as public policy the development and implementation of economically feasible and environmentally safe strategies for the reduction of solid waste. This law set a goal of 35 percent for the recycling rate, which almost three decades later revolves around 14 percent⁶⁶. The reconstruction process provides an opportunity to develop local recycling markets for glass and tires.

In Puerto Rico, most of the construction material for bricks and cement mix is extracted from quarries found in the karst region. The northern karst region contains Puerto Rico’s most extensive freshwater aquifer, largest coastal wetland and estuary, the largest continuous expanse of mature forest, and most extensive underground cave systems. A pilot project is recommended to use recycled glass as an aggregate material in construction. In addition to diverting materials and creating recycling markets, this action would protect the karst ecosystem, which is vital for Puerto Rico.

There is a local business in San Sebastián, Puerto Rico that uses recycled glass for the development of construction bricks. Although there is an opportunity for other local businesses to tap into this initiative⁶⁷, a needs and market study should be carried out to identify specific markets for recycled materials in the Island. Then, market and capital incentives can be considered to promote and boost new entrepreneurship in this sector.

This project would reduce the amount of glass and other materials deposited in landfills. It would also increase recycling rates, extend the useful life of landfills, create jobs, and protect important natural resources. This action could potentially lead to a more comprehensive recycling initiative, beyond glass and tires.

Potential Lead

Puerto Rico Solid Waste Management Authority

Potential Co-leads

PRHBA; PRMA; Puerto Rico Chapter of the AGC; PRIDCO; EQB; EPA; DNER; Puerto Rico Recycling Partnership

Potential Funding Sources

Economic Development Administration Grants; EPA Recycling Innovation Funds

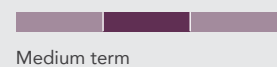
Unmet Needs



Crosscutting Benefits



Timeframe



Description

Conventional agriculture commonly uses large amounts of energy, water, pesticides, fertilizers, and other chemicals, and discharges pollutants into the soil and water. This program entails the (1) selection of priority conventional agriculture sites, (2) identification of best practices, (3) implementation partners and resources, and (4) the development of monitoring networks to determine the environmental benefits of incorporating sustainable agriculture practices. It will be valuable to study the impact of this transition on a variety of ecosystems and related services.

The program will include the following sustainable agricultural practices:

- Water and soil best management practices, including green infrastructure projects.
- Water use reduction and reuse, including wastewater recycling and gray water or rainwater harvesting.
- Sustainable pest management.
- Energy reduction and efficiency.
- Solid waste reduction, including composting.

The program will target farmers across Puerto Rico, but two priority areas that could become pilot projects are the south coast aquifer and the dairy farms in the north coast aquifer. This action will reduce the number of contaminants entering the water and will protect natural resources and improve their resilience. It will also reduce operational costs in the farms and will improve farmers’ resilience to climate events, like flooding and droughts.

Potential Lead

Puerto Rico Department of Agriculture

Potential Co-leads

DNER; EQB; USDA (Natural Resources Conservation Service); Caribbean Climate Hub; AES

Potential Funding Sources

NRCS Wetlands Reserve Enhancement Partnership; Environmental Quality Incentives Program; USEPA Water Pollution Control (Section 106) Grants

Unmet Needs



Crosscutting Benefits



Timeframe



Short term

Develop an emergency preparedness and response plan for Puerto Rico’s natural resources.

Description

Damages to natural resources have enormous environmental and economic impacts. Hurricane María provided important lessons regarding natural and ecological preparedness and recovery. It also stressed the importance of developing emergency preparedness and response plan that includes: (1) assessment of needs and capabilities, (2) required training for a response, recovery, and reconstruction, (3) improvements needed on coordination and communication, and (4) strategies to manage volunteers and resources.

This plan should:

- Document federal and Commonwealth processes and requirements to ensure that the knowledge acquired by Commonwealth staff prevails in the institutional memory.
- Define coordination between federal and Commonwealth agencies, municipalities, and NGOs.
- Be based on assessments of post-María efforts, such as (1) the removal of grounding vessels, (2) debris cleaning, management, and disposal, and (3) marine debris and species management, among other.

This strategy will strengthen institutional capabilities to cope with natural hazards, such as storms, earthquakes, floods, droughts, and climate change effects.

Potential Lead

Puerto Rico Department of Natural and Environmental Resources

Potential Co-leads

EQB; PRDPS; USFWS; USFS; NRCS; Para La Naturaleza; San Juan Bay Estuary Program; Ciudadanos del Karso; NGOs with cooperative or management agreements with the DNER

Potential Funding Sources

FEMA Pre-Disaster Mitigation Grant Program

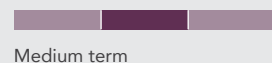
Unmet Needs



Crosscutting Benefits



Timeframe



Description

The creation of urban and rural community gardens provides multiple environmental, economic, and social benefits. Community gardens increase agricultural production and make food more accessible to the population. This program could be part of a joint municipal strategy of economic development and environmental protection.

Community gardens play an essential role in the revitalization of urban areas. They reduce the carbon footprint from packaging and transport, promote local economic development, provide a source of income to underserved populations, and provide health benefits. Community gardens also encourage citizen engagement and community cohesion, while improving access to healthy food.

A robust community garden project will create jobs in farming, composting, and distribution, among others. Municipalities can offer mini-grants to support urban agriculture. Additionally, funds can be available for agricultural production, aggregation, and distribution.

The Bosque Modelo Office, under the Puerto Rico Department of Natural and Environmental Resources (DNER), has expressed interest in supporting this initiative. Also, the Agricultural Extension Service at the University of Puerto Rico in Mayagüez provides technical support for the development of such programs.

Potential Lead

Office for the Community and Socioeconomic Development of Puerto Rico and Municipalities

Potential Co-leads

DNER; PRDA; USDA; NRCS; AES

Potential Funding Sources

CDBG-DR – Small Business Loan or Grant Program; EPA – Environmental Education Grant; NRCS – Environmental Quality Incentives Program; FEMA (Green infrastructure projects that reduce flooding in structures under the NFIP may be eligible)

Unmet Needs



Crosscutting Benefits



Timeframe



Medium term



05

RESOURCES

Glossary

Agroecology

The application of ecological principles to agricultural systems and practices, or the branch of science concerned with this.

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 and in quantity that can be extracted.

Barrier Islands

A long, narrow sand island that is parallel to the mainland and serves to protect the coast from erosion. Barrier islands typically have dunes along the exposed outer side, zones of vegetation in the interior, and swampy areas along the inner lagoon.

Beach Nourishment

A “soft armoring” practice of adding large quantities of sand or sediment to beaches to combat erosion and increase beach width.

Buyout programs

Buyout occurs when a public agency negotiates the purchase of homes from private homeowners. There are many different reasons for buyouts: the homes may be blocking a public construction project, or lying in a hazardous area, such as a floodplain, where there is a strong risk of costly damage.

Carbon Footprint

The total amount of greenhouse gases that are emitted into the atmosphere each year by a person, family, building, organization, or company. A person’s carbon



footprint includes greenhouse gas emissions from fuel that an individual burns directly, such as by heating a home or riding in a car. It also includes greenhouse gases that come from producing the goods or services that the individual uses, including emissions from power plants that make electricity, factories that make products, and landfills where trash gets sent.

Coastal setbacks

A prescribed distance to a coastal feature (such as the line of permanent vegetation) within which all or certain types of development are prohibited. Specific characteristics of the beach and backshore environments must be considered in determining an appropriate setback.

Combined Sewer Overflow

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

Conservation

It is the care and protection that is given to a sector or property designated as a natural, cultural or ecological resource of great value, with the purpose of improving and maintaining its natural conditions and characteristics; allows limited and careful use.

Disaster

Severe alterations in the normal functioning of a community or a 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. Means any natural catastrophe (including any hurricane, tornado, storm, high water, wind-

blown water, tsunami, earthquake, volcanic eruption, landslide, landslide, snowstorm or drought), or, regardless of the cause, any fire, flood, or explosion, in any part of Puerto Rico that, in the determination of the President, causes damage of sufficient severity and magnitude to justify an important disaster assistance to supplement the efforts and available resources of the state, local government and disaster relief organizations to alleviate the damage, loss, hardship or suffering caused by it.

Effectiveness

The degree to which something is successful in producing an intended or expected result, success or purpose.

Efficiency

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

Effluent

The liquid or gaseous wastes discharge, with or without treatment 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 to build and sustain 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.

Floodplains

Flat or semi-flat land normally dry and susceptible to flooding by water from a natural source.

Geological fault

A planar or gently curved fracture in the rocks of the Earth's crust, where compressional or tensional forces cause relative displacement of the rocks on the opposite sides of the fracture.

GIS – Geographic Information System

A framework for gathering, managing, and analyzing data, spatial location and organizes layers of information into visualizations using maps. Rooted in the science of geography, GIS integrates many types of data.

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 workers' duties involved in making their 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, under the bed or 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 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 shock and stress faced by a sector, location or community 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 the city'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 city 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 operation. Exchange of information between systems enables them to function collectively and respond rapidly through shorter feedback loops throughout the society.

Land use

Land use refers to the total of arrangements, activities, and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation).

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.

Maritime Terrestrial Zone

Area of the coasts or maritime borders of Puerto Rico and its bordering islands that bathe the sea in its recede and flow, where the tides are sensitive, and the largest waves in the storms where they are not sensitive, and includes the lands gained at sea, the accessions and landings caused by it and the margins of the rivers to the place where it is navigable or the tides become sensitive.

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.

Nature-based solutions

The International Union for Conservation of Nature defines as actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.

Non-point source

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

Nongovernmental 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.

Open Spaces

Any open piece of land that is undeveloped (has no buildings or other built structures) and is accessible to the public.

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 sectors, 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 the 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 on a 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, and should not be an externality of inefficient design.

Reflective

Accepts the inherent and ever-increasing uncertainty and change in today's world. They have mechanisms to continuously evolve and will 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

It provides the bases 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 (for example, 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 for the storage of water.

Resilience

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

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.

Ridge-to-reef

Initiative to manage waters from source to sea - healthy and well-managed river basins and coastal areas where people and nature thrive.

Risk Potential consequences in which something of value is in danger with an uncertain outcome, recognizing the diversity of values. Often the 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.

Robust

Robust systems include well-conceived, constructed and managed physical assets, so that they can withstand the impacts of hazard events without significant damage or loss of function. Robust design anticipates potential failures in systems, making provision to ensure failure is predictable, safe, and not disproportionate to the cause. Over-reliance on a single asset, cascading failure and design thresholds that might lead to catastrophic collapse if exceeded are actively avoided.

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 city, including: earthquakes, floods, disease outbreaks, terrorist attacks.

Storm Surge

An abnormal rise in sea level accompanying a hurricane or other intense storm, 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 generates 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 and ecosystems predisposition to suffer damage as a result of intrinsic and contextual conditions that make it plausible that such systems, once impacted, collapse or experience damage and major 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

Those needs of communities or families that have not been able to be 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

Are groups and communities at a 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, although 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, as regulators of hydrological regimes and as habitats of abundant biodiversity.



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 Naguabo, PR. Jeff Gunn

06

APPENDIX



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 Framework¹⁰ and The Rockefeller Foundation's City Resilience Framework¹¹.

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,



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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.

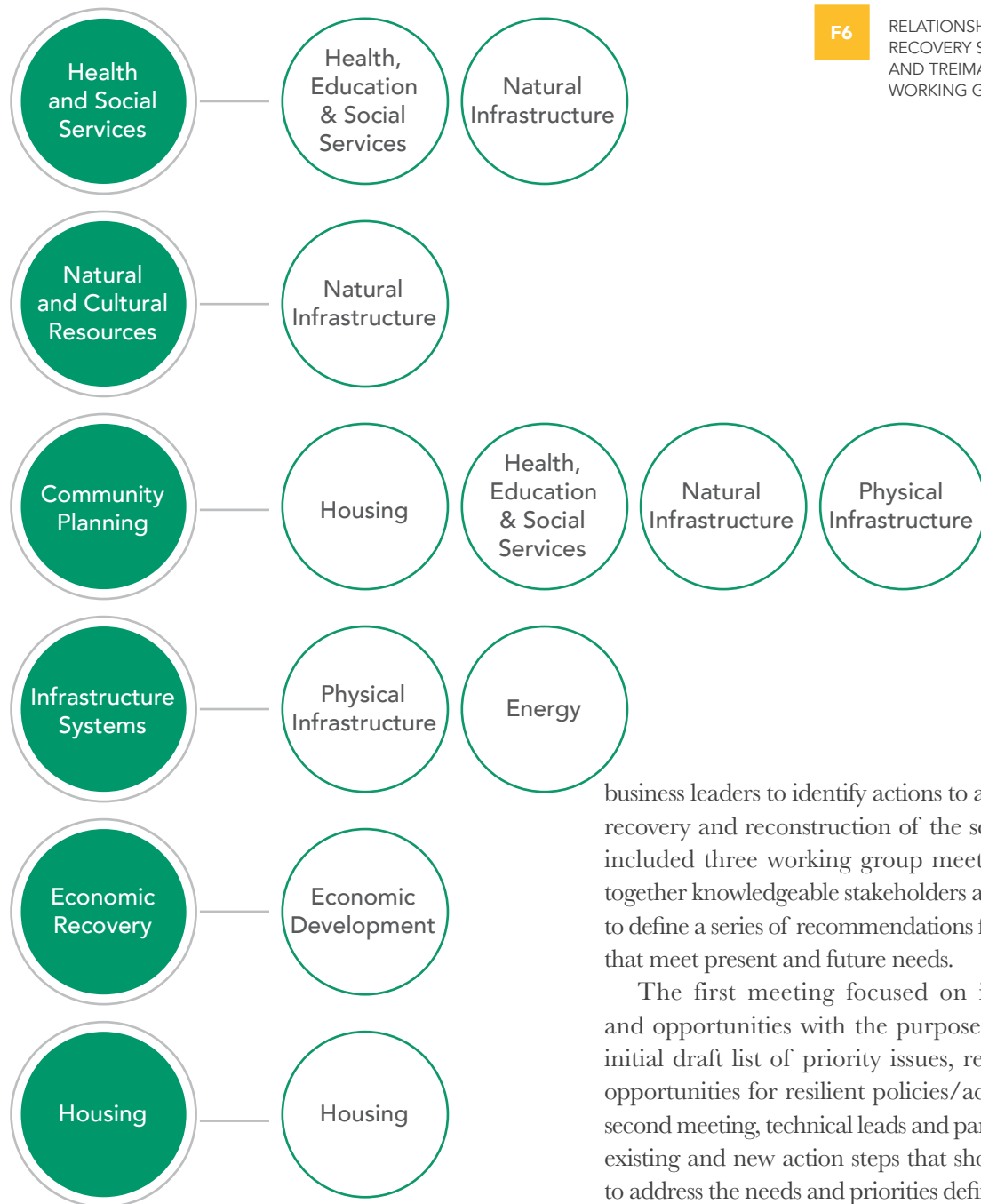
- 1. Effective leadership & management
- 2. Empowered stakeholders
- 3. Integrated development planning

- 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



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 NDRE, 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 interdependencies. 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 geographical 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.

February

PUBLIC SECTOR ADVISORY GROUP

1st Public Sector
Advisory Group
Meeting

WORKING GROUPS

1st Working
Group
Meetings:
Identification of
Opportunities

OUTREACH & ENGAGEMENT

1st Youth
Participatory
Photography
Session

2nd Youth
Participatory
Photography
Session

F7

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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