Design for Community Resilience in the Age of Disasters:
A Case Study in Puerto Rico

By

Yiyuan Qin

B.A. with Honors in Environmental Science, Colby College, 2012
Master of Environmental Management, Yale University, 2015

Submitted to the Integrated Design and Management Program in partial fulfillment of the requirements of the degree of

MASTER OF SCIENCE IN ENGINEERING AND MANAGEMENT
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

MAY 2020

Signature of Author: _____
Yiyuan Qin
Integrated Design & Management Program
May 15, 2020

Certified by: _____
Jason Jay, Senior Lecturer
MIT Sloan School of Management
Thesis Supervisor

Certified by: _____
Miho Mazereeuw, Associate Professor
MIT School of Architecture + Planning
Thesis Supervisor

Accepted by: _____
Matthew S. Kressy, Executive Director
Integrated Design & Management Program

Page intentionally left blank

ABSTRACT

Design for Community Resilience in the Age of Disasters:
A Case Study in Puerto Rico

By

Yiyuan Qin

Submitted to the Integrated Design and Management Program on
May 15, 2020 in partial fulfillment of the requirements of the
Degree of Master of Science in Engineering and Management

In September 2017, Puerto Rico, home to 3.2 million people, suffered catastrophic damages as category-5 Hurricanes Irma and Maria made direct landfalls on the Island. Their effects on people's health and safety were devastating and long-term. In the face of climate change, places like Puerto Rico are likely confronted with more frequent and more destructive natural disasters. The need to better prepare the Island for future disasters is immense and urgent. Combining primary and secondary research, this thesis applies a human-centered and system-minded design approach to identify and analyze the current strengths and gaps in the disaster response and recovery efforts in Puerto Rico after Hurricane Maria. I conducted interviews and participatory observations with individuals and organizations in the field, ranging from community-based organizations to aid agencies. This thesis reveals that although Hurricane Maria touched virtually all parts of the Island, the vulnerable populations were disproportionately affected. In response to the inefficiencies of local governments and federal agencies, citizens and community groups emerged to respond to the aftermath of Hurricane Maria. However, there is a clear gap in the current disaster management system in engaging and empowering citizens and communities to respond to the growing challenges of natural disasters. Based on these findings, this thesis lays out a set of design recommendations for leveraging disaster information and knowledge management systems to promote collaboration across key actors to enhance disaster resilience in Puerto Rico and other relevant contexts.

Thesis Supervisors:
Jason Jay, Senior Lecturer at MIT Sloan School of Management
Miho Mazereeuw, Associate Professor at MIT School of Architecture + Planning

Page intentionally left blank

ACKNOWLEDGMENTS

Wise woman and one of my favorite writers, Elizabeth Gilbert, wrote in her book *Big Magic*, "Your creative work is not your baby; if anything, you are its baby." My feelings precisely. Over the past year, this project forged me in new ways that I had not imagined and am forever grateful for. Throughout the process, I am tremendously fortunate to have had an army of mentors, critics, friends, and families that marched along with me. There are no words of appreciation that can measure up to what they have gifted me.

First and foremost, my gratitude goes to my thesis advisors Jason Jay and Miho Mazereeuw, who supported me through my struggles to find my voice amidst all the complexities of my thesis journey. Jason's hands-on guidance and heartfelt advising were the light that led me through the thick of wayfinding. Miho's gentle push for appreciative inquiry anchored me to listen with an open mind. They stuck with me as I grappled with learning the art and science of "taming" an expansive qualitative research project while juggling with other life's trials. I learned that instead of being the master of my work, my job is to give voice to the voiceless.

Along with my advisors, throughout this past year of exploration and learning, the following individuals generously helped me navigate the deep waters of disaster management and the wilderness of human-centered design processes: Professor Daniel Aldrich (Northeastern University), Lily Bui (MIT), David Boardman (Citi Ventures), Jen Shuang (Citi Ventures), Chris Kasabach (Watson Foundation), Pedro Colon-Hernandez (MIT), and Erez Yoeli (MIT). This thesis would not be what it is without their constructive feedback and encouragement.

This project is dedicated to all my Puerto Rican families and friends who inspired me with their stubborn optimism and unbreakable strength. I owe a tremendous debt to all the individuals that welcomed me with their open arms and hearts. Their generosity and kindness throughout my fieldwork kept me going strong. In particular, I would like to offer my heartfelt thanks to the leaders and volunteers of COSSAO, ACUTAS, CAM Las Carolinas, and Center for Transformation, whose tenacity and resourcefulness are the backbones of a rising Puerto Rico. I would also like to thank the following individuals and organizations, whose knowledge and wisdom were exceptionally illuminating in my quest to better understand the post-Maria Puerto Rico: David Carrasquillo (Hispanic Federation), Professor Pablo A. Méndez Lázaro (University of Puerto Rico), All Hands and Hearts, PRxPR, Center for New Economy, ReImagina PR, Resilient Power PR, Response Innovation Lab, ConnectRelief, Servicios Legales de PR, and Parallel 18.

The fieldwork of the thesis was made possible with the generous funding from MIT's Sandbox, IDEAS Social Innovation Challenge, Priscilla King Gray Public Service Center Fellowships, and Integrated Design and Management Program.

This thesis is an extension of my first-year IDM spring design project, and I would like to thank my teammates, Sharon Yan and Jairo Rodriguez, for their contributions during the early explorations.

Much gratitude also goes to my colleagues in Puerto Rico who have been part of my entrepreneurship journey at different stages: Francisco Nieves, Yari Padilla, Jonathan Days, and Andrew Ferenczi. And to Danielle Goldman and Mariellen Jewers at the Open Avenues Foundation for the opportunity for me to continue growing as an entrepreneur with ARC that was built from this thesis after graduating from MIT.

Matt Kressy, Tony Hu, Andy MacInnis, Amanda Peters, and other staff members at IDM have been my biggest champions and cheerleaders during my time at MIT. The program empowered me to trust the iterative, exploratory, and generative nature of design as I embarked on this journey in a territory with few markings.

I would not have had the confidence and capacity to handle this mammoth undertaking weren't for my mentors and teachers from Colby College, International Honors Program, Watson Foundation, Yale University, and the World Resources Institute, who had set the foundation for me to continue growing as an interdisciplinary scholar and advocate for a better planet.

My long stretches of fieldwork in Puerto Rico would not have been complete without the fun road trips, salsa dancing, surfing excursions, and mofongo and pana feasts with my friends on the Island: Sarah Park, Miguel Machado, Carmen Miranda, Ana Iris Correa and family, Tito Valentín and family, Danny Skate, and Jesús Rodríguez.

This writing thesis during a pandemic was admittedly difficult, to say the least. Throughout my thesis journey over the past year, my friends, near and far, kept me sane and happy by sharing long conversations, food, music, companionship, movies, dancing, working over zoom, and much more. My biggest thank-yous go to Siyang Xu, Alan Zhang, Casper Enghuus, Yifei Feng, Dipo Doherty, Rachael Petersen, Lauren Kerr, Marion Dierickx, Brooke Tjarks, Jie Pan, Derrick Strickland, and Stephen Guerra.

Finally and most importantly, my deepest gratitude goes to my mom and dad for their unconditional love and support through all of my crazy adventures.

I still remember the first time when I watched the sun dipping into the ocean by el Morro in Old San Juan in January 2017. In the three years that followed, Puerto Rico endured the most destructive hurricane and the largest political movement; I also experienced the greatest crucibles in my adulthood. Through this thesis project, the universe has conspired for me to learn one important lesson: it is the people around you that will get you through any hardships. In Puerto Rico, communities that banded together are rising up from the rubbles stronger. As I look back at my time at MIT, with the support from the above-mentioned people and more, I feel ever more confident and empowered as I march onward even into a world of uncertainty, and I am hopeful that no hurricane will stop the Boricua's quest for joy in solidarity on la Isla del Encanto.

TABLE OF CONTENTS

CHAPTER 1: BACKGROUND

1. Puerto Rico and Hurricane Maria

In September 2017, Puerto Rico, home to 3.2 million people, suffered catastrophic damages as category-5 Hurricanes Irma and Maria made landfalls on the island (Segarra 2017). Puerto Rico was in the direct path of Hurricane Maria, of which wind speeds reached 155 mph and the eyewall drove across the island over a 40-hour period. Surge, tide, wind, and rainfall devastated the island with inundation, floods, and landslides (Almukhtar et al. 2017; Pasch, Penny, and Berg 2019)(Figure 1-1).

The hurricanes' effects on people's health and safety were devastating and long-term. Damages to homes and critical infrastructure resulted in prolonged cascading failures in essential services: energy, telecommunication, water, transportation, health services, schools, and much more. Hurricane Maria caused over $90 billion in damage, approximately 3,000 to 5,000 deaths, and an exodus of more than 150,000 people in the two months after (Chinoy 2018; Segarra 2017; Kishore et al. 2018). Hurricane Maria was the most destructive hurricane in Puerto Rico's modern times, and third costliest in U.S. history (after Katrina in 2005 and Harvey in 2017) (Pasch, Penny, and Berg 2019).

Figure 1-1. Hurricane Maria's path across Puerto Rico in 2017 (Almukhtar et al. 2017).

Given the scale of the disaster, a plethora of challenges further compromised the response and recovery process. With limited resources and personnel, the distribution of resources and coordination among actors were plagued by the lack of information and communication due to failed energy and telecommunication systems, geographic separation of Puerto Rico, and limited access to some remote parts of the island. Residents lacked electricity, food, water, and medical care

for up to months. After the hurricanes, people lost their jobs, schools were closed, government services and private enterprises could no longer operate effectively. While the hurricanes touched virtually all segments of the population, poor older adults, children, individuals with disabilities or chronic illnesses, and women were disproportionately affected by this disaster (COR3 and Government of Puerto Rico 2018).

Even before Maria hit, the archipelago had already been facing recession for over a decade, where half of its residents lived below the poverty line — the highest poverty rate of a U.S. state or territory — and the unemployment rate is more than double the national level (U. S. Census Bureau 2019a; Klein 2018; COR3 and Government of Puerto Rico 2018). Years of economic contraction led to a severe fiscal crisis, resulting in high and unsustainable levels of debt that led to the passage of the Puerto Rico Oversight, Management, and Economic Stability Act (PROMESA) in 2016. PROMESA has been restricting the amount of resources the Puerto Rican government can mobilize locally for disaster response and recovery (Rodríguez-Díaz 2017).

As an unincorporated territory, Puerto Rico's response to Hurricane Maria was also influenced by this status and various legislation and acts imposed on Puerto Rico influenced, including the Merchant Marina Act of 1920, known as the Jones Act. The Jones Act requires that U.S. agencies control maritime waters and ports of Puerto Rico, which leads to higher costs of consumer good imports to Puerto Rico and restrained access to non-US vessels and crews (Rodríguez-Díaz 2017).

As a result of the financial hardships, along with socioeconomic and governance challenges, infrastructure repairs and maintenance was deferred, including telecommunication and energy systems, transportation networks, and public buildings (COR3 and Government of Puerto Rico 2018). Years of deterioration of infrastructure eventually led to catastrophic failures in the face of a powerful disaster like Maria.

Lastly, the economic challenges and lack of opportunities led to a major decline in its population, as a result of younger workers leaving an elder, poor population. This demographic shift also added to the stress on the Island's economy, creating a shortage of professional workers in many sectors such as infrastructure. These preexisting conditions — economic crisis spanning more than a decade, colonial legacy, and other structural, demographic, health, social, and infrastructure stresses — had led Puerto Rico to a particularly vulnerable position, exacerbating the impact of natural disasters like hurricanes (Klein 2018; Sullivan 2018).

2. Government Response to Hurricane Maria

The archipelago of Puerto Rico includes the main island and several smaller islands, such as Culebra and Vieques. Puerto Rico contributes to the annual appropriation of funding to the Federal Emergency Management Agency (FEMA), the agency responsible for disaster response on the Island. In the aftermath of Hurricanes Irma and Maria, Major Disaster Declarations were signed, authorizing FEMA to provide assistance programs for the individuals and public institutions in Puerto Rico, in coordination with the Government of Puerto Rico and the Island's municipalities.

FEMA was also tasked to coordinate recovery efforts across federal and state-level agencies, private sector entities, and voluntary, faith-based, and community organizations across the Island.

The 2017 Hurricane Season was one of the most active in U.S. history. Three major hurricanes in quick successions - Harvey (August 25), Irma (September 6), and Maria (September 19) - were of unprecedented scale, scope and impacts, overwhelming response and recovery capabilities at all levels of government. As of April 30, 2018, FEMA reported that $21.2 billion had been obligated towards the impact of these hurricanes, and over 17,000 FEMA personnel and nearly 14,000 staff from the Department of Defense had been deployed (FEMA 2018). However, many criticisms have been leveled at the agency on its response to Hurricane Maria in Puerto Rico (Robles 2018; Clement, Zezima, and Guskin 2018). A study comparing federal disaster responses to 2017 Hurricanes Harvey, Irma, and Maria found that the federal government responded on a larger scale and much more quickly across measures of money and staffing to Harvey and Irma in Texas and Florida, compared with Maria in Puerto Rico, of which the variation was not commensurate with storm severity and need (Willison et al. 2019) (Figure 1-2).

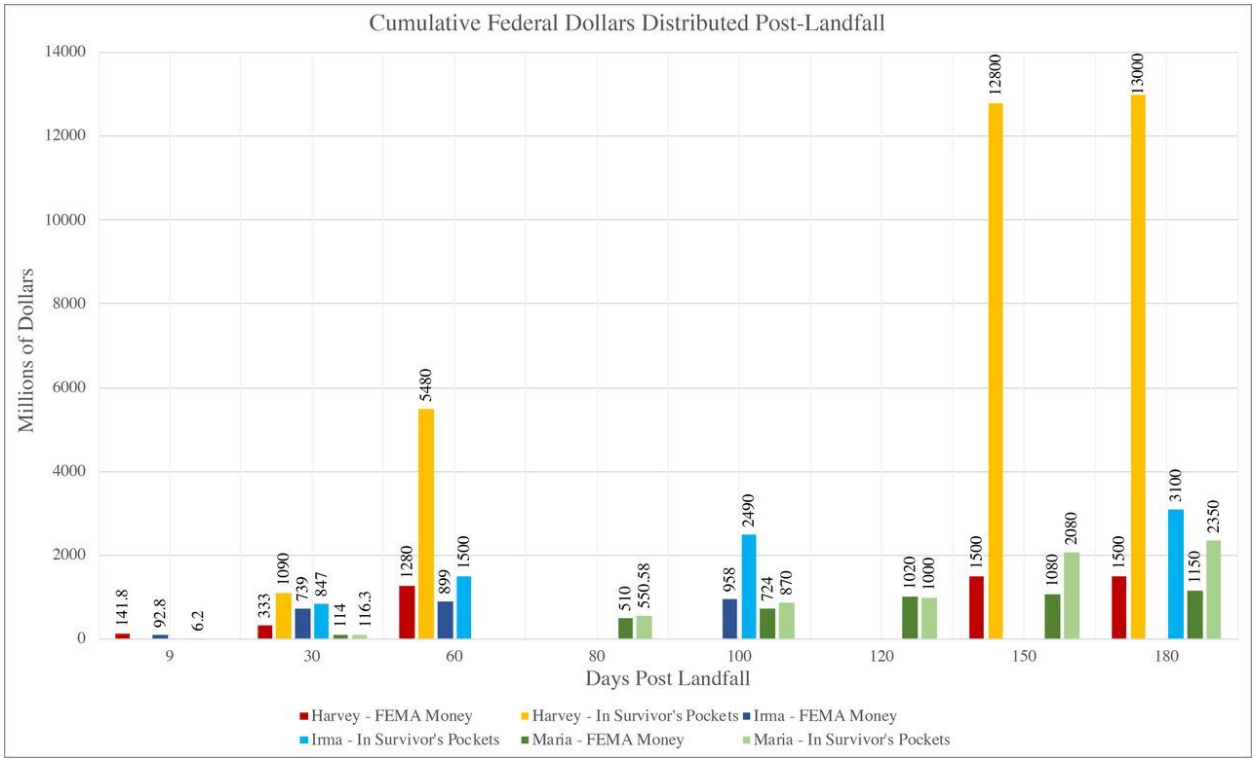


Figure 1-2. Cumulative dollars scaled in millions 6 months post-landfall. Federal Emergency Management Agency (FEMA) money refers to FEMA assistance to individuals and families. This includes applications by individuals currently residing in the USA post-Maria, as well as persons in Puerto Rico. In Survivor's Pockets includes total count of federal aid to survivors by days post-landfall, including FEMA aid to individuals and families, Small Business Association Loans, and National Flood Insurance payouts (Willison et al. 2019).

In FEMA's After-Action Report (AAR) on the 2017 Hurricane Season, the agency acknowledged that it failed to properly prepare for the hurricane season and was unable to provide adequate support to those affected in Puerto Rico (FEMA 2018). The agency vastly underestimated the impacts of the

hurricane season in Puerto Rico and the ensuing complications from the structural challenges facing the Island's infrastructure and governance. In every category represented, the planning for Puerto Rico's Hurricane Maria response was severely insufficient to mitigate the impacts caused by the hurricane, including population, cellular services, power outages, hospitals, and areas needed search and rescue (Figure 1-3).

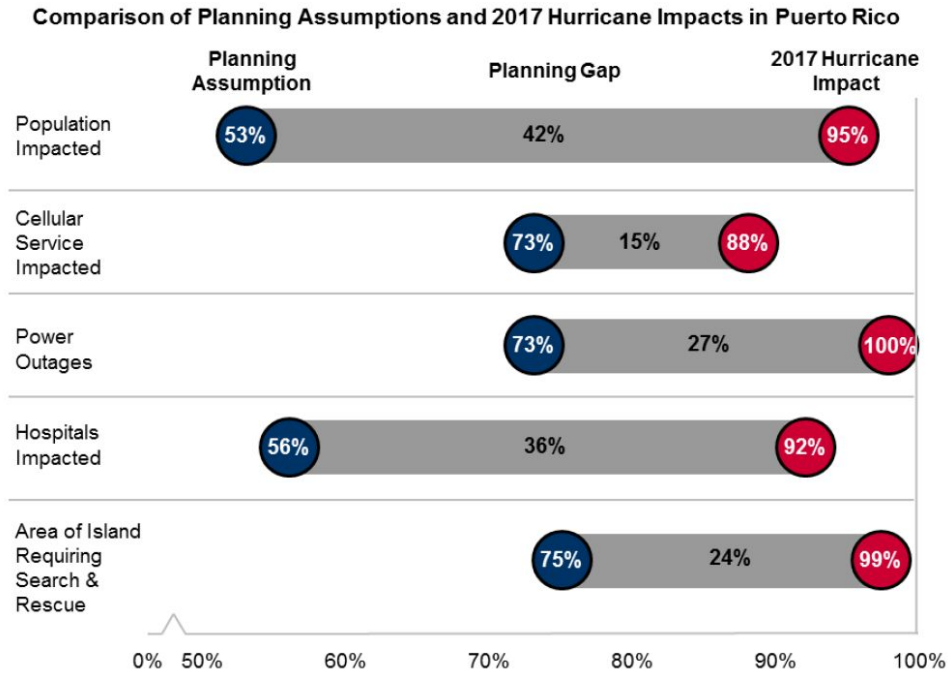


Figure 1-3. FEMA underestimated impacts of 2017 hurricanes in Puerto Rico (FEMA 2018).

Before Maria hit the Island, Puerto Rico's emergency supply warehouses had been emptied as many supplies were routed to the U.S. Virgin Islands in response to Hurricane Irma. It took FEMA longer than expected to secure and deliver supplies, while it failed to keep track of the moving resources amidst the chaos. The dire lack of generators had left many medical facilities without emergency power. The AAR also found that FEMA had thousands fewer qualified workers than it needed going into the hurricane season, and disaster personnel were deployed to other storms before Maria. They had to borrow workers from other agencies to manage the immense demand. Using the last assessment for Puerto Rico from 2012, FEMA did not account for insufficiently maintained infrastructure and the financial and political challenges facing the Puerto Rican government in 2017. As a result of unexpected communication outages and the limited availability and applicability of satellite phones, it was extremely difficult for FEMA to gain situational awareness, further impeding action. The insufficient response received by Puerto Rico had led to increases in mortality and adverse health outcomes in the aftermath of the hurricanes (Willison et al. 2019).

In the AAR, FEMA recognized the importance of building a culture of preparedness from individuals to all levels of government, the call for adaptation and collaboration, and the need to reduce the complexity of FEMA. For places like Puerto Rico, FEMA urged communities not to count so heavily

on FEMA in a future crisis. The agency administrator, Brock Long, wrote in the draft report, "The 2017 hurricane season showed that all levels of government — and individual families — need to be much better prepared with their own supplies, particularly in remote or insular areas where commodities take longer to deliver" (Robles 2018).

One year after Hurricane Maria, many people in Puerto Rico were still struggling with basic necessities. According to a poll, Puerto Ricans saw a failure in the government response to Hurricane Maria at all levels, including municipal governments, the Puerto Rican government, and federal agencies, and gave negative ratings to President Trump and Governor Ricardo Rosselló (DiJulio and Muñana 2018). There were major concerns about whether authorities would be able to help should another storm hit the Island; the majority worried that the government was still not prepared to deal with future hurricanes and believed that most Puerto Ricans were not ready.

The discontent towards government disaster response and concerns over government transparency on recovery funds spending, along with fury over years of recession, mismanagement, and corruption, ignited prolonged, sweeping protests against the government in the summer of 2019. One of the largest ever seen on the island, the demonstrations eventually led to the resignation of the embattled governor, Ricardo A. Rosselló, leaving the Island with greater political instability (Robles and Rosa 2019; Hernández et al. 2019).

3. The Rise of Citizens and Community-Based Organizations

In response to the inefficiencies of local governments and federal agencies, complicated by existing challenges facing the Island, citizens and community groups emerged to respond to the aftermath of Hurricane Maria. Amongst the structural challenges and the lag of government support, many grassroots community-based organizations (CBOs) across the Island transformed themselves as important frontline pioneers in lifting communities and particularly vulnerable populations up from the devastation (Posada 2018).

It's estimated that during the first months after Maria, some 200,000 people joined CBOs and other non-profit entities as volunteers, each dedicating 23 hours of work and helping more than one million Puerto Ricans (Alicea 2018). Many of these CBOs newly emerged after the hurricane, while those that had already existed before nearly all dramatically modified their services to meet the new humanitarian crisis at hand (Agosto-Maldonado 2018). More than half of the surveyed entities distributed essential supplies such as water or food, while others also collected debris. The communities and nonprofit sector were the first, and in many cases, the only responder to the disaster. With trust and knowledge of local needs, and recognized by emergency management agencies, CBOs have become a key player in preparing Puerto Rico for future disasters (FEMA 2018). However, many of these organizations are still struggling with challenges from limited funding, small staffs, and other management barriers to sustaining their mission in helping their communities recover from Maria and prepare for future disasters (Agosto-Maldonado 2018).

4. Thesis Objective and Outline

In the face of climate change, places like Puerto Rico are likely confronted with more frequent and more destructive natural disasters such as hurricanes (Keellings and Ayala 2019; Harmsen et al. 2009; Chinoy 2018). As seen in post-Maria Puerto Rico, the need to better prepare the Island, especially for the vulnerable populations, for future disasters is immense and urgent.

As natural and human-made disasters grow in scale and severity, governments at all levels are already grappling with the limitations of their resources and capacities, exposing widening access and service gaps. As today's changing demographic and technology trends make the effects of disasters more complex to manage, engaging and empowering individuals and communities to become a more integral part of enhancing disaster resilience has become undeniably vital. FEMA defines this collective approach as "Whole Community" (FEMA 2011):

> *"As a concept, Whole Community is a means by which residents, emergency management practitioners, organizational and community leaders, and government officials can collectively understand and assess the needs of their respective communities and determine the best ways to organize and strengthen their assets, capacities, and interests. By doing so, a more effective path to societal security and resilience is built."*

Truly realizing the whole community approach in building resilience will require the disaster management community to transform their thinking, planning, and practices. However, currently, there is limited guidance on how to connect the dots among key players in the disaster management community and to effectively leverage the strengths, resources, and best practices of communities and citizens in response to disasters.

Combining primary and secondary research, this thesis applies a human-centered and system-minded design approach to identify and analyze the current strengths and gaps in the disaster response and recovery efforts in Puerto Rico after Hurricane Maria. Based on these findings, the thesis then lays out a set of design recommendations for designing disaster management policies and programs to better engage and empower communities and citizens to build a more resilient future for places like Puerto Rico. The following core questions guide the development of the thesis:

- How were communities impacted by Hurricane Maria and what factors contributed to the disparities across the island?
- How did communities and disaster management and aid agencies respond?
- How might we help the island become more resilient in the age of disasters?

Chapter 2 reviews relevant literature on the concept of resilience and the role of disaster information and knowledge management. Chapter 3 explains the primary and secondary research processes deployed to answer the core questions. Chapter 4 first details the impacts of Hurricane Maria and the vulnerabilities exposed and then highlights how citizens and community groups

responded to the disaster. Chapter 5 further illustrates these lessons through a case study. Chapter 6 provides a set of design recommendations for scholars and practitioners to explore possible pathways towards a more resilient future. Chapter 7 discusses the findings and lays out limitations and future work.

CHAPTER 2: LITERATURE REVIEW

1. Core Concepts in Disaster Research

The main objective of the thesis addresses disaster resilience building particularly in Puerto Rico and other relevant contexts. Consolidating existing literature, this thesis builds on core concepts in disaster research. Because the concepts are complex, multidimensional, and evolving, here I clarify and synthesize the most relevant and widely-used concepts and findings to set the context for the study. These concepts in disaster research have complex interactions among them and cannot be sufficiently understood by focusing on any single aspect alone. Definitions used in this study primarily come from indicators and terminology developed by the United Nations Office for Disaster Risk Reduction (UNDDR).

Disasters are serious disruptions of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of *exposure, vulnerability, and capacity*, which leads to one or more human, material, economic, and environmental losses and impacts (UNDRR 2017; Perry 2017; Quarantelli 2000).

A *Hazard* is characterized as a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption, or environmental degradation (UNDRR 2017; Gill and Ritchie 2017). The causes for hazards can be natural (e.g. floods, hurricanes, and earthquakes), technological (e.g. nuclear radiation, toxic wastes, and dam failures), and anthropogenic (e.g. wars, deforestation, and fire).

Exposure refers to the situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas(UNDRR 2017; Gill and Ritchie 2017). To measure exposure, common indicators can include the number of people or types of assets in an area. These measures can be combined with the specific vulnerability and capacity of the exposed elements to any particular hazard to estimate the associated quantitative risks.

The concept of *vulnerability* has emerged in various research fields (disaster risk management/reduction, development, resilience, and climate change adaptation) and schools of thought (political economy, social-ecology, political ecology, etc.), resulting in different approaches to access and define vulnerability (Birkmann 2006; Adger 2006). The UN/ISDR defines vulnerability as the conditions determined by physical, social, economic, and environmental factors or processes which increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards. It is important to note that measurement of vulnerability is often fuzzy, indirect, conditional on a hazard, and linked to complex dynamics of inherent characteristics of communities and social-ecological systems (Birkmann 2007).

Capacity is the combination of all the strengths, attributes, and resources available within an organization, community, or society to manage and reduce disaster risks and strengthen resilience (UNDRR 2017). Capacity is often categorized as coping capacity and adaptive capacity. Coping

capacity is often used to describe the availability of resources and the ability to utilize these resources to respond to hazards; while adaptive capacity includes the capacity of communities and societies to adapt to future hazards and climate change (Gallopín 2006; McCarthy et al. 2001).

Resilience describes the ability of a system, community, or society to absorb, accommodate, adapt to, transform and recover from the adverse consequences and impacts of a hazard in a timely and efficient manner (UNDRR 2017; Birkmann 2006). Building resilience is seen as a key strategy for individuals, communities, and social-ecological systems to live with changing conditions. Studies have attempted to build frameworks to assess community resilience, drawing from indicators in categories including social, economic, institutional, and infrastructure resilience, as well as community capital (Cutter, Burton, and Emrich 2010).

The term *disaster risk* is widely recognized as the consequence of the interaction between a hazard and the characteristics that make people and places vulnerable and exposed as well as their capacity to cope and adapt, which is often expressed in the following equation (DasGupta and Shaw 2017; Pelling 2003):

$$Disaster\ Risk\ =\ (Hazard\ \times Exposure \times Vulnerability) / Capacity$$

The equation illustrates the interdependent nature of the core concepts in disaster research and demonstrates the opposing tension between risk and resilience: where hazard, exposure, and vulnerability increases disaster risk whereas capacity increases resilience (Berkes 2007).

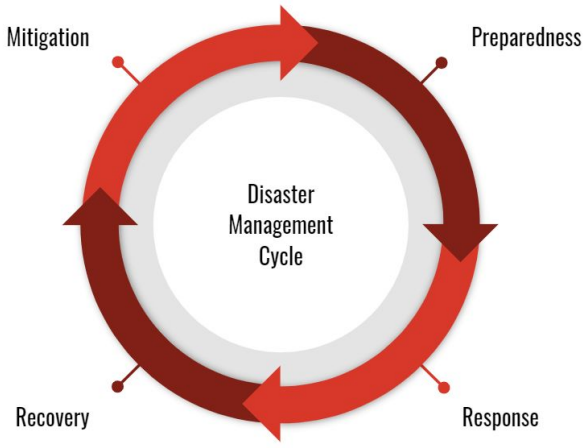


Figure 2-1. The four continuous phases of the disaster management cycle.

Disaster Risk Management is the application of *Disaster Risk Reduction* policies and strategies, aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development. Disaster Risk management is an ongoing process and often illustrated as a continuous cycle of four phases: *mitigation, preparedness, response, and recovery* (UNISDR and UNOCHA 2008)

(Figure 2-1). Mitigation involves actions taken to prevent or reduce the impacts of disasters; preparedness includes activities of planning, training, and educational for events that cannot be mitigated; response involves assistance or intervention that occurs in the immediate aftermath of a disaster; and recovery includes efforts to restore or improve the condition of affected communities and reduce vulnerability to future disasters.

2. Resilience and Disasters

Despite being able to identify the causes of risk, researchers and practitioners have failed to eradicate it (McCreight 2010). Disaster researchers and policymakers alike have instead centered their focus on the pragmatic value of disaster resilience in the past two decades (Rodríguez, Donner, and Trainor 2018; Cutter, Burton, and Emrich 2010). For researchers, it is an explanatory framework to understand and explain how social, built, or natural systems can withstand or quickly recover from shocks and avoid their collapse due to internal vulnerability. For policymakers and officials in disaster management, resilience helps frame disaster preparedness and guide capacity-building initiatives. Building on the key concepts and frameworks in disaster research, resilience brings together the many threads — vulnerability, capacity, hazards, and exposure — and aspires to determine the factors that make systems more or less able to withstand and recover from disasters.

Table 2-1. Key elements of resilience and example factors.

Element	Example Factors	References
Socioeconomic	household income; employment; tax revenues; education level; home ownership; business size; population density; age; access to services; communication capacity; special needs; insurance coverage	Cutter, Burton, and Emrich 2010; Cutter, Ash, and Emrich 2014; Mayunga 2007; Aldrich 2012
Ecological	quality, extent, and diversity of natural systems (wetlands, forest, parks)	Sutton-Grier, Wowk, and Bamford 2015; Tyler and Moench 2012
Institutional	governance; municipal expenditure on services; interoperable communication; institution climate; emergency plans; hazard mitigation plans; zoning and building standards; training; disaster aid experience	Cutter and Finch 2008; Cutter, Burton, and Emrich 2010; Cutter, Ash, and Emrich 2014; Aldrich 2012
Infrastructure	number, quality, and location of housing, shelters; critical infrastructure (water, energy, communication, transportation); medical care capacity; industrial supply chain; backup resources	Mayunga 2007; Cutter and Finch 2008; Cutter, Burton, and Emrich 2010; Cutter, Ash, and Emrich 2014
Social Capital	number of local organizations; voting rates; volunteerism; levels of trust; sense of community; participation in local events; organizational linkages and cooperation; access to people in leadership; place attachment; political participation	Mayunga 2007; Aldrich 2012; F. H. Norris et al. 2008; Cutter, Burton, and Emrich 2010; Cutter and Finch 2008

This study mainly focuses at the community level resilience — the collective ability of a neighborhood or geographically defined area to deal with stressors and recover following shocks, with the understanding that resilience of individuals and organizations within the community are integral components of resilience at different scales (Aldrich and Meyer 2015). Based on studies in disaster resilience, capacities are often broadly grouped as socioeconomic, ecological, institutional, infrastructure, and social capital (Cutter, Burton, and Emrich 2010; Kendra, Clay, and Gill 2018). Table 2-1 summarises examples of key elements and factors used in disaster research.

One of the factors, social capital has been at the forefront of thinking about resilience. Social capital is broadly defined as the social networks and relations that can have positive consequences for the individual and the community based on social cohesion, trust, and reciprocity (Portes 1998; Meyer 2018). It refers to the ideas of unity, togetherness, a sense of shared identity and community, cooperation, and community action (Dekens 2007). Individual and community social capital networks can provide information, aid, financial resources, and child care along with emotional and psychological support (Aldrich and Meyer 2015). These social support networks can function as the most crucial means of adjustment for the most vulnerable groups. In general, greater social capital (the phrase social networks is used interchangeably in this study) provides information, knowledge, and access to network members; strengthens trustworthiness across the network; and builds new norms about compliance and participation among network members (Aldrich 2012).

These mechanisms of social capital have been witnessed to allow communities to recover from disasters faster with citizens and organizations responding to helping others in times of crisis (Whittaker, McLennan, and Handmer 2015). Anecdotes and quantitative studies have been recorded from around the world, including the 1910 earthquake in San Francisco, the 2001 September 11 terrorist attacks in New York, the 2004 tsunami in the Indian Ocean, the 2005 Hurricane Katrina in New Orleans and surrounding areas, the 2010 earthquake in Haiti, the 2011 3/11 disasters in Japan (Aldrich 2012; 2019; Solnit 2009; Jones 2018). With growing evidence and improved measurement, many disaster researchers have pointed to social capital as a vital, perhaps even decisive attribute of social systems that influence a community's ability to respond and recover from disasters (Nakagawa and Shaw 2004; Aldrich 2012; Cutter, Ash, and Emrich 2014; Adger 2003). However, practitioners have underutilized social cohesion and social networks in disaster planning and management (Aldrich 2012).

Aside from the widely accepted benefits, it is also important to note that the effects of social networks on affected populations can be multifaceted and the relationship between social capital and disaster is dynamic and complex (Aldrich 2012; Solnit 2009). Under pressure from extreme disasters, social networks sometimes can reinforce previously existing inequalities for the more peripheral groups, and they don't benefit all individuals the same way even within the same network (Adger 2003). Disasters may also alter the social fabric of disaster-affected neighbors — toward altruistic cooperation or occasionally toward violent dysfunction — for a short period of time, while the pre-disaster conditions may play a bigger role in the post-disaster social networks.

3. Disaster Information and Knowledge Management

Information and knowledge management is foundational to achieving effective disaster response and recovery. Preparedness and effectiveness of disaster management rely on the process of acquiring, analyzing, and sharing quality data to support decision-making around logistics, supplies, and cooperation among relief agencies, which face complex operational challenges. In response to large-scale disasters, decision-makers often face tremendous time pressure and uncertainty to allocate scarce resources, which could lead to severe, sweeping consequences (Jiang et al. 2012). Emergency operations can be further impeded by damaged communication, energy, and transportation infrastructure in the wake of disasters. The disaster management community needs a large variety of information in this time and mission critical process to perform different tasks at different phases around decision making and situational awareness, including generating early warnings, planning for response and recovery activities, evaluation of disaster severity, and distribution of relief actions and supplies (Zhang, Zhou, and Nunamaker Jr 2002). Information needs also vary across different stakeholders. For example, disaster relief workers need information about dispatch of supplies; agency officers demand access to disaster situations, and availability of staff and resources; philanthropic entities require assessments of victims' needs. In most disaster operations, the need to gather, analyze, and share timely, comprehensive, and reliable information is paramount.

Even though there has been a considerable increase in disaster-related research and scientific activities, as well as advances in technology (e.g. satellite coverage and surveillance technology), disaster damage and loss is still on an upward trend (White, Kates, and Burton 2001; Dekens 2007). There are clearly gaps and barriers between the complex interaction of knowledge production, sharing, and implementation. Studies have found that poor information and knowledge management in disaster management can lead to disaster propagation and higher levels of casualties (Jiang et al. 2012). Given the diverse and distributed nature of information and knowledge across different entities, the challenges around disaster information and knowledge management are multifold and complex, particularly around sharing and coordination (Spiekermann et al. 2015; Zhang, Zhou, and Nunamaker Jr 2002; White, Kates, and Burton 2001; Bharosa, Lee, and Janssen 2010).

Often stored away and difficult to access, knowledge is most commonly lost or fragmented due to inadequate coordination, partnership, communication, and sharing (Spiekermann et al. 2015). Research around disaster information and knowledge management show that the lack of knowledge is not the key challenge, but rather the problems lie with risk interpretation and understanding, mentalities across scales, power structure, personal attitudes, values, and other constraints across individual, community, and agency levels (Bharosa, Lee, and Janssen 2010; Spiekermann et al. 2015; McConnell and Drennan 2006). Spiekermann et al. (2015) identified three types of barriers to the fragmentation of knowledge, including functional barriers related to resource issues (divergent objectives, needs, scope, priorities, and lack of cooperation); structural

barriers related to institutional settings and standards; and social barriers related to factors such as trust, values, understanding, and communication.

Due to many of these barriers, a key component of the disaster knowledge space — local knowledge and practices in disaster risk reduction — has not been adequately incorporated into the official channels of disaster management (Milliken and Linton 2015; Mercer et al. 2010; Liboiron 2015; Corburn 2003; Dekens 2007). While the importance of local knowledge — "what the residents know about natural hazard risks and what they believe and do about them in a given situation" — has been recognized and advocated in relation to disaster risk reduction, particularly for the most vulnerable populations, the practical application has been limited and marginalized (Mercer et al. 2010; Dekens 2007). Some key factors that prevent the inclusion of local knowledge are ideological (e.g. the conventional or scientific knowledge is "superior"), institutional (e.g. it's difficult to use local knowledge because of their "invisibility," complexity, diversity, and changeability), and political (e.g. disasters are issues around national defense and security). The oppression of local knowledge is a reflection of the structural marginalization, exploitation, powerlessness, violence, and denial of the people who bear the knowledge, which often are the root causes of their vulnerability to disasters (Mercer et al. 2010; Liboiron 2015; Dekens 2007).

Participatory approaches to disaster management acknowledge local knowledge and people as the primary actors, providing an entry point for promoting local people's participation with "higher-level" institutions that already have a comparative advantage. In the context of complex, changing, and growing hazards, understanding, accounting for, and respecting local knowledge can help agencies improve their disaster management planning, as well as project performance, acceptance, ownership, and sustainability (Dekens 2007). Therefore, although there are many challenges to the documentation and use of local knowledge in disaster management, working with communities to integrate their knowledge system on an equal and respectful basis has the potential to serve as an effective tool for building overall disaster resilience (Mercer et al. 2010; Dekens 2007; Spiekermann et al. 2015).

To bridge these functional, structural, and social barriers across the heterogeneous actors in disaster information and knowledge sharing and coordination, the concept and role of boundary objects and activity theory have shown promise as theoretical foundations in cross-border collaboration in disaster management (Engeström 2000; Carlile 2002; Bharosa et al. 2012). The introduction of socio-technical objects (e.g. information systems) in combination of processes to promote cross-border collaboration (e.g. inclusive governance and communication mechanisms that involve all stakeholders) has found to be helpful in overcoming various challenges.

4. Summary

In light of the existing literature in disaster management, a set of premises emerged as guidance for my research:

- Improving disaster resilience through capacity building instead of eliminating risk is central to meeting disaster management objectives;
- Social capital — individual and community networks — have proven to be a vital capacity for coping and adapting to shocks from disasters;
- Local knowledge is a key component of disaster information and knowledge management, but it is often ignored, due to functional, structural, and social barriers; and
- Leverage the existing strength and innovation to enhance collaboration across key actors in the system to achieve disaster resilience goals.

CHAPTER 3: METHODS

To identify and analyze the current strengths and gaps in disaster management in Puerto Rico, I conducted both primary and secondary research. Based on the findings, I then developed a set of recommendations for designing disaster management policies and programs, with continuous feedback and inputs from a subset of the study participants. The research process was inherently adaptive and iterative, where relevant new insights and discoveries allowed for new questions and explorations, in order to serve the overall objective of identifying points of intervention for improving disaster resilience.

1. Secondary Research

The secondary research methods involved literature review and archival research using materials from three main sources: 1) expert recommendation; 2) published work in journals and research institutions; and 3) news and multimedia.

I first created a foundational list of work recommended by people with academic and professional experience and expertise in relevant fields. This list consists of representative works on core theories and definitions on disaster and climate, disaster information systems and knowledge management, methodologies for disaster risk reduction planning, behavior and psychology, organization and management, and entrepreneurship.

Building on the bodies of work recommended by experts, I used Google, Web of Science, and Google Scholar to search the extent of published articles, reports, case studies, and government documents relevant for the study. Select keywords used for the search include disaster management, response, or recovery; climate change, resilience, vulnerability, or risk; communities; information or knowledge. I prioritized materials with a focus in Puerto Rico and the United States. Additional materials were included from citations.

I also reviewed relevant news and multimedia materials in English and Spanish languages, including documentaries, videos, and podcasts on disaster management, particularly post Hurricane Maria in Puerto Rico. Some of the news media sources include the New York Times, the Atlantic, Miami Herald, and El Nuevo Dia.

Lastly, I extracted, organized, and synthesized applicable information to inform and guide field research and development of design principles and recommendations.

2. Field Research

To uncover the unmet needs in this new and understudied circumstance after Hurricane Maria in Puerto Rico, I conducted both exploratory and targeted field research in the form of in-person and

phone interviews, group interviews, and participatory observations. I traveled to Puerto Rico for field research on three occasions: March 22th to 30th, 2019; July 22nd to September 1st, 2019; and January 11th to February 1st, 2020. During two of my field trips, two major natural disasters — Hurricane Dorian (August 24, 2019) and a series of earthquakes (January 2020) — took place, where I participated in disaster preparation and relief work. Both of these experiences informed my research.

2.1 Study Participants

Throughout the study, I spoke with a wide range of approximately 100 individuals both in Puerto Rico as well as at research institutions and other entities, in relevant fields of disaster and emergency management, humanitarian aid, sustainability, business and management, environmental and urban planning, healthcare, technology and entrepreneurship, and community organizing. These individuals represent scholars in academic institutions, professionals in national, international, and Puerto Rican non-profit organizations, government agencies, leaders, and volunteers in CBOs, as well as community residents. These individuals were primarily identified based on their professional connections as well as through snowball sampling in the field. The following sections will detail the characteristics of some of the key participants. Pseudonyms and professional titles were used in the study.

2.2 Main Study Sites

During my field research in Puerto Rico, there were four main study sites where I conducted extensive interviews, group interviews, and participatory observations. The sites are located in different municipalities, including Caguas, Utuado, Toa Baja, Yabucoa, Humacao, Yauco, and Ponce (Figure 3-1). These sites were selected based on expert recommendation, presence of existing leadership in community organizing, access to study participants, and high exposure and vulnerability to climate-related disasters such as hurricanes. Among the main study sites, all were affected by Hurricane Maria and were among the municipalities with the highest increase in crude mortality rates post-hurricane (Andrade et al. 2018). Yauco and Ponce were also severely affected by the most recent earthquakes in January 2020.

1) The *Centro de Apoyo Mutuo (CAM)* (Center of Mutual Support) in the semirural neighborhood of Las Carolinas in Caguas emerged in the Apoyo Mutuo (mutual support) movement in the aftermath of Hurricane Maria (Molinari 2019). In Las Carolinas, of the community's 2,500 residents, 60 to 70 percent are over 55 years old and one in three households live below the poverty line (U. S. Census Bureau 2020). Since 2013, the community has lost 20 percent of its population, leaving elderly residents behind with little family support. After Hurricane Maria, Las Carolinas residents were without water service for three months, without electricity for seven months, and without municipal debris pickup for 80 days. In response to the needs, community organizations such as CAM in Las Carolinas, Caguas, opened community kitchens to feed the communities. Women residents of the neighborhood occupied the closed María Montañez Gómez elementary school, transforming the space into a communal space with a community kitchen, a healing center, an activity room for the elderly, a garden, and a thrift store. Today, volunteers of CAM, mostly women

and elderly, continue to prepare and home deliver over 100 meals three times a week along two routes to senior and bedridden residents and their caregivers.

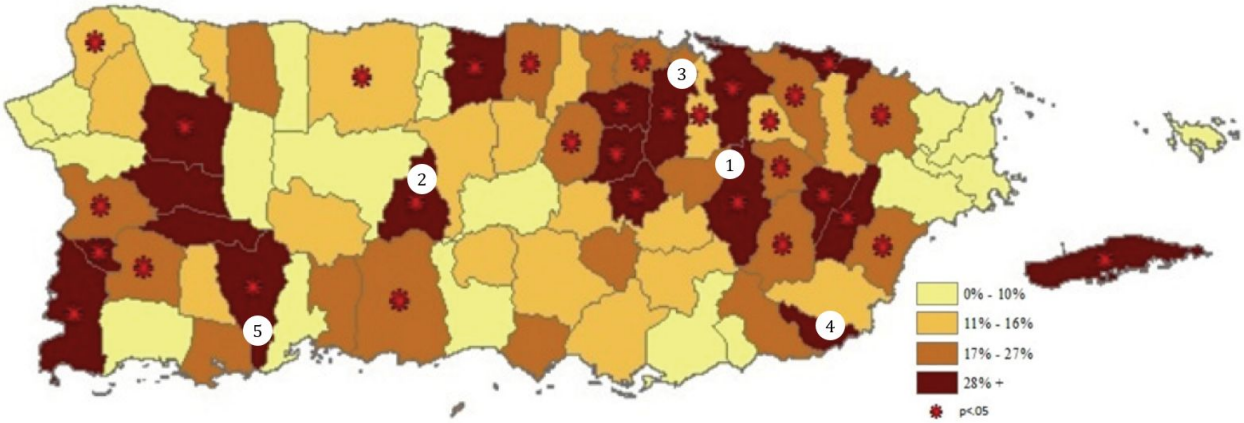


Figure 3-1. The municipalities where the five main study sites are located: 1) Caguas; 2) Utuado; 3) Toa Baja; 4) Yabucoa and Humacao; and 5) Yauco and Ponce. Map on estimated percentage increase in crude mortality rates by municipality in Puerto Rico from September 2017-February 2018 (Source: Andrade et al. 2018).

2) The *Corporación de Servicios de Salud Primaria y Desarrollo Socioeconómico El Otoao (COSSAO)* (Corporation for the Health and Socioeconomic Development of Otoao) is a community-based organization established in 2013 in the remote, central mountainous region of Puerto Rico. COSSAO provides free health services to 5,000 households across seven communities: Frontón in Ciales, Mameyes Arriba in Jayuya, and the Caonillas communities, Don Alonso, Tetuán, and Mameyes in Utuado. Before COSSAO, residents of these rural communities often had to travel for hours to reach the nearest healthcare facility. Today, in addition to the primary health facilities in Mameyes, in collaboration with Heart to Heart Foundation, COSSAO employs seven health workers that visit residents to access and document their health and socio-economic conditions, with hopes to provide a roadmap to better serve the most vulnerable populations in case of another disaster.

3) The *Asociación de Comunidades Unidas Tomando Acción Solidaria (ACUTAS)* (Association of United Communities Taking Solidarity Action) shares a similar origin as CAM in Las Carolinas. Serving hundreds of households in Villa Calma, Ingenio, and Villas del Sol of Toa Baja today, ACUTAS was started days after Maria by a group of women who provided help to their community residents from a house, where water, electricity, and other support were delayed for months after the hurricane. The communities that ACUTAS is serving suffered severe flooding after the hurricane and a large percentage of the households live under the poverty line (Ferré-Sadurní 2017). Today, ACUTAS provides workshops and after-school programs for adults and children, mental health services, and initiatives to help small businesses.

4) Yabucoa and Humacao are municipalities located in the southeastern part of Puerto Rico and considered ground zero of the hurricane, bore the brunt of Hurricane Maria on September 20th, 2017 while still recovering from damage brought by Hurricane Irma (Segarra 2017). International organizations like All Hands and Hearts (a volunteer-powered disaster relief organization that

addresses the immediate and long-term needs of communities impacted by natural disasters) have been providing assistance to the communities such as home repairs. For 32 years, the *Asociación Recreativa y Educativa Comunal del Barrio Mariana de Humacao, Inc. (ARECMA)* (Communal Recreation and Education Association of Mariana, Humacao) has been serving residents of Humacao through community-centered activities and projects. In response to Maria, a new Center for Transformation was created equipped with solar panels, safe shelter spaces, laundry services, and even spaces as part of the community's effort to build disaster resilience.

5) Yauco and Ponce were among the southern municipalities that were seriously affected by a series of over a thousand earthquakes, including a magnitude 6.4 earthquake and dozens above 4, in early 2020 in Puerto Rico. Thousands of people have lost their homes and many more have been sleeping outside for fear that their houses will collapse on them at any moment (Ortiz-Blanes 2020). Across the most affected municipalities, preliminary damage was estimated to be over $460 million. Volunteer disaster relief efforts to help the southern part of the Island were organized by NGOs, universities, government agencies, as well as individuals.

2.3 Interviews

I conducted interviews with individuals from academic and research institutions, international and Puerto Rican NGOs, philanthropic entities, government agencies, the private sector, independent consultants, and leaders of CBOs. Most of the interviews were done in person, with the exception of seven conducted over the phone due to geographic differences. Some of these interviews were conducted with multiple individuals at the same time. With some individuals, follow-up conversations and meetings were held to clarify details and expand on the topics. Table 3-1 summarises the number of interviews and affiliation of the interviewees.

Table 3-1. Summary of interviews.

Affiliation	Number of Interviews/Interviewees
Academic/Research	26
Community-Based Organization	12
Government	3
NGO (International)	17
NGO (Puerto Rico)	10
NGO/Philanthropy (Puerto Rico)	7
Private Sector	9
Independent	5
Total	98

Interviews lasted from 30 minutes to 90 minutes. Interviews conducted with professionals and community leaders in Puerto Rico were audio-recorded with participants' verbal consent. Written notes and pictures were taken on site. These interviews were primarily conducted in English. Interviews with scholars focused on their area of expertise and feedback on the project. Varying depending on the context, interviews were semi-structured with professionals and community leaders generally focused on addressing the following questions:

- What were the organization's core mission and structure?
- What was the organization's experience of Hurricane Maria?
- How did projects and activities evolve in response to Hurricane Maria?
- Arc of project development: planning, financing, staffing, and implementation
- What type of technology or tools are used in projects?
- How is information and knowledge managed?
- What is the process of working with other people and organizations?
- What were some of the greatest challenges the organization has faced post-Maria: financial, management, external, and socio-political?
- What are some of the lessons learned and how could things be done differently?
- How were vulnerable populations considered?
- What is your personal motivation for being part of the efforts?

2.4 Group Interviews

With the help of community-based organizations and community leaders, I conducted group interviews with representatives of the residents in the main study sites. These group interviews were conducted in Spanish and facilitated with the help of an English-speaking local interpreter except for two meetings in Utuato. The interviews were audio-recorded with the participants' verbal consent. I took notes in Spanish and English, and then transcribed and translated the audio-recordings in English.

1) Las Carolinas. I conducted a 50-minute group interview with 6 members of the community during one of the sessions programmed for elderly members of the community at the CAM. There were three men and three women present, aged from 50 to 89 years. Three of them live alone, two with their elderly spouse, and one with her daughter and grandson. The interview was semi-structured and the following questions were addressed:

- What were the greatest needs before, during, and after (short and long-term) hurricanes?
- What are some of the coping strategies that work well?
- Who's providing these services?
- What needs are not yet met with what's in place?
- How are they participating in the community?
- What types of changes may be desired?
- What are the perceived barriers in participating in community life?

- Have they had volunteers coming to visit? Would they like that? What would they want them to help with? What types of concerns might they have?
- Would they be comfortable with sharing information with organizations to provide services on disasters?

2) Mamayes, Utuado. I conducted three group interviews with the general community residents, including a 30-minute interview with two volunteer members of COSSAO at the organization's office; a 60-minute session with approximately 30 members of a local faith-based group in their church; and a 45-minute meeting with four teaching staff of a local kindergarten at their school.

3) Ingenio, Toa Baja. I met with three of the community leaders of ACUTAS and two of the community members at the ACUTAS office in Toa Baja. We had two 2-hour meetings in August 2019 and one 90-minute meeting in January 2020. One of the community members relies on a wheelchair for movement.

For group interviews in Mamayes, Utuado, and Ingenia, Toa Baja, the interviews were semi-structured and following questions were addressed:

- Have they had volunteer experience before? If so, what was the motivation, and how was the experience like?
- How did they and the community react to Hurricanes?
- How has the community changed after Hurricane Maria?
- How would they like to prepare differently for future disasters like hurricanes as a community?
- If a volunteer program is put in place, how could we motivate more people to participate?
- How do communities convene and communicate with each other?
- How do communities engage with elderly members?
- What are the values that the community looks to represent? What do they take pride in as a community?

2.5 Participatory Observations

Lastly, I joined activities of CBOs as well as disaster relief efforts after the January earthquakes as part of my participatory observations. During these activities, I was accompanied by the staff of the organizations where I observed, asked questions, and documented with pictures, notes, and geolocations. The activities were conducted in Spanish and English.

1) Health promoters program with COSSAO. I accompanied two health promoters on two different routes in two days for their in-house visits, interviews, and data collection. We visited eight households in two days. I also participated in the COSSAO staff meetings where they demonstrated their data management process.

2) All Hands and Hearts housing repair program. I spent a week at their project site in Yabucoa, joining their volunteer groups repairing homes, damage assessments, and staff coordination meetings.

3) Earthquake disaster relief efforts in Ponce and Yauco. I joined two groups of Puerto Rican disaster relief efforts after the series of January earthquakes. On January 12th, I joined the Hispanic Federation's operation to distribute donated disaster relief supplies in Ponce. On January 18th, I joined a brigade of health professionals organized by the University of Puerto Rico, where we visited three refugee camps and individual households in two communities in Yauco.

3. Design Recommendation Development

Based on primary and secondary research and informed by widely used disaster management frameworks, I deployed a human-centered, system-minded process to derive design recommendations for creating a more inclusive and effective disaster information and knowledge system to help improve disaster resilience. I conducted analyses of needs and capacity analyses for key actors and evaluated the strengths and gaps of current solutions in meeting the key actors' needs. Given the exploratory nature of this study, the process was continuously adaptive, iterative, and generative as I sought feedback and inputs from study participants throughout the process. The objective of the recommendations is to invite scholars and practitioners alike to explore some potential points of intervention to improve community resilience for places like Puerto Rico.

CHAPTER 4: RESULTS

I present findings from a combination of primary and secondary research on Hurricane Maria's impacts on communities, factors that contributed to the disparities across the Island, and the emergent response and recovery efforts from citizens and CBOs. Pseudonyms are used when reporting accounts from field research. Long quotes from interviewees are italicized and indented. Accounts from field research are reported in English, with the exceptions of organization names, local terms, and direct quotes, which are italicized with translations in parentheses.

1. Impacts of Hurricane Maria

Located in the northeast Caribbean Sea, the archipelago of Puerto Rico is exposed to a range of natural hazards including hurricanes, earthquakes, tsunamis, landslides, subsidence, and flooding (Palm and Hodgson 1993). In 2017, Hurricane Maria brought extreme rainfall over Puerto Rico, registering the highest precipitation of 129 storms that have impacted the island since 1956 (Keellings and Ayala 2019). The hurricane caused devastating and lasting damages to Puerto Rico while exacerbating existing environmental, social, and economic challenges already crippling the Island. With record-breaking wind gusts, heavy rains, storm surges, floods, and landslides, the 2017 storm took thousands of human lives, forced approximately 150,000 people to leave the Island, damaged over 1 million homes, cut off essential services and supplies across the Island for months, weakened deteriorating infrastructure, and ravaged the Island's agricultural yields and natural landscapes (Niles and Contreras 2019; Irfan 2017; Robles and Ferré-Sadurní 2017; Kishore et al. 2018; Hinojosa and Meléndez 2018b; 2018a). The Government of Puerto Rico estimated that the Island would need $94.4 billion to fully recover (Resilient Puerto Rico Advisory Commission 2018). Below is a summary of the main socio-economic impacts of Hurricane Maria.

1.1 Loss of Lives

From September 2017 to February 2018, an estimate of 3,000 to 5,000 deaths occurred either directly related to the hurricane (eg, drowning, flying debris, building collapse, and electrocution) or the ensuing unsafe conditions that contributed to injury, illness, or unavailability of service (Andrade et al. 2018; Kishore et al. 2018; Santos-Burgoa et al. 2018; Fink 2018). Studies have found that excess deaths were highest among elderly men and largely attributed to illnesses such as heart disease, diabetes, and Alzheimer's (Cruz-Cano and Mead 2019; Andrade et al. 2018). This excess mortality was equivalent to over 60 percent increase in the mortality rate as compared with the same period in 2016 (Kishore et al. 2018). However, the number likely to be an underestimate due to survivorship bias, survey limitations, difficulties in communication, population movement, and disruption to services including government records, death certificates, and mortuary services (Gay et al. 2019; Andrade et al. 2018).

1.2 Disruption to Services and Supplies

After Hurricane Maria, many parts of the Island experienced extended periods of disruption in essential services as a result of severe damages to the Island's aging infrastructure (The New York Times 2017). The hurricane caused complete disruption of power, damaged telecommunication towers, roads, bridges, and schools, and destroyed 80 percent of crop value. Furthermore, the hurricane impacted the structural integrity of most hospitals and healthcare facilities and affected 70 percent of the water treatment and distribution system (Resilient Puerto Rico Advisory Commission 2018). On average, households went 84 days without electricity, 68 days without water, and 41 days without cellular telephone coverage (Kishore et al. 2018; Hinojosa and Meléndez 2018a).

Among all the service disruptions, issues with medical services were among the highest with 31 percent households reporting, of which the greatest problems include the inability to access medications, need for respiratory equipment and other devices and procedures that require electricity (i.e. insulin, dialysis, and cancer treatments), and closed medical facilities or lack of doctors (Robles 2017; Kishore et al. 2018; Rodriguez 2018). The disruption in healthcare services accounted for one third of the deaths (Kishore et al. 2018).

Before the Hurricane, Puerto Rico already experienced a much higher rate of food insecurity than other parts of the US, worsened by the severe lack of homegrown food as the Island imported 85 percent of the food, mostly from the U.S. (Coleman-Jensen et al. 2018; Acevedo 2018). This figure rose to 95 percent after Hurricane Maria (Mares 2019). After the storm, with no power or water, damaged homes, low supplies, many people could not afford to eat hot meals or just to find food (Allen and Peñaloza 2019; Mares 2019; Gillespie, Romo, and Santana 2017). Furthermore, with roadblocks and port closures, emergency relief supplies — food, water, fuel, medicine — could not be delivered to the hurricane victims (LaRocco 2017).

1.3 Housing Challenge

After Maria, over 1 million or 90 percent of all homes on the Island were determined to have suffered some degree of damage, of which 250,000 with major damages and 70,000 destroyed (Hinojosa and Meléndez 2018b; Viglucci 2018; Garcia 2020). Estimated at about $37 billion, housing was the largest category of storm destruction in Puerto Rico (Brown 2018). With a history of informal construction, Puerto Rico has been facing a housing crisis before the hurricane. Driven by deep poverty and decades-long formal housing shortages, these informal constructions, built without following land use codes or building standards and often found in disaster-prone areas, bore the brunt of the storm in 2017 (Viglucci 2018). As a result, along with other historical and cultural reasons (i.e. land inheritance), hundreds of thousands of Puerto Ricans live on land to which they have no formal titles or deeds. After Maria, FEMA's requirement for homeownership documentation precluded 60 percent of federal aid applicants from accessing funding to rebuild (Garcia 2020). Today, more than two years after Maria, a vast swath of the population still live

without proper shelter, leaving them at the risk of increased injury or damage in the event of any future hurricanes and other disasters.

1.4 Displacement and Emigration

Months after the hurricane, unable to cope with the aftermath of the storm, approximately 150,000 Puerto Ricans (about 4 percent of the population) left the Island and relocated to the continental U.S. (Sutter and Hernandez 2018; Hinojosa and Meléndez 2018a). While the Island's population had been shrinking for years, following the extended power outages, precarious living conditions, and difficulty in accessing basic supplies, the exodus marked the greatest migration in Puerto Rico's history (Resilient Puerto Rico Advisory Commission 2018; Sutter and Hernandez 2018). The massive emigration post-Maria reinforces the challenges induced by years of depopulation, further leading to decreased government services and employment, the closing of schools, and increased poverty especially among the most disadvantaged such as those with children and the elderly (Hinojosa and Meléndez 2018a). Those that relocated have also reported challenges of finding jobs, housing, medical services, and schooling (C. Méndez-Nuñez 2018; Silva 2018).

1.5 Mental Health Impacts

Major natural disasters events often impose an array of stressors, including threats to one's life and safety, exposure to human trauma, bereavement and loss, social and community disruption, and ongoing hardships. These stressors often inflict damage to people's mental health and can lead to increased outcomes such as anxiety, depression, and posttraumatic stress disorder (PTSD) (F. Norris et al. 2002; F. H. Norris, Friedman, and Watson 2002). The duration and severity of the trauma experienced by Puerto Ricans from Maria have led to a worsened mental health crisis on the Island as well as those relocated, particularly for the youth, elderly, women, and those in low-income areas (Lybarger 2018; Scaramutti et al. 2019; Orengo-Aguayo et al. 2019; Greenbaum 2019; Varney and Kane 2018).

In the months following Hurricane Maria, the overall suicide rate increased 29 percent, while the rate more than doubled for people aged 65 to 69 and tripled for those aged 75 to 79 (Varney and Kane 2018; Wyss 2018b; Burnette 2019; Varney 2018). In the hardest-hit, low-income southeast coastal community of Punta Santiago, one study found that two thirds of the respondents had clinically significant symptoms either in depression, anxiety, or PTSD (Ferré et al. 2019). In a survey conducted one year after Maria, over one-fifth of the Island's residents reported needing or receiving mental health services (Greenbaum 2019). Other ensuing consequences include spikes in drug use, domestic violence against women, as well as burnout and secondary trauma among caregivers and emergency responders (Roure 2019; Vigaud-Walsh 2018; Greenbaum 2019). Today, still confronted with a great lack of access to mental health services and prevalent stigma influencing the perceptions of mental health, the challenges from the "aftermath of the aftermath" in Puerto Rico are still dire (Resilient Puerto Rico Advisory Commission 2018; Negroni et al. 2020).

2. Vulnerabilities Exposed

Disproportionately affecting the most vulnerable, Hurricane Maria has exposed Puerto Rico's stark inequalities. Determined by physical, social, economic, and environmental factors or processes, vulnerability is a measure of the state of susceptibility of a population to harm from exposure to the impacts of hazards and from the absence of capacity to adapt (Adger 2006; Cutter, Boruff, and Shirley 2003; Birkmann 2007; Berke et al. 2010). Studies have found that the most common characteristics that define vulnerable populations include race/ethnicity, socioeconomic class, gender, age (elderly and children), health, and housing tenureship, of which many antecedent risk factors are also accelerated and/or magnified by disasters (Cutter and Finch 2008; Ngo Ehren B. 2001). Furthermore, vulnerability factors tend to cluster, multiplying the risk of certain segments of the population (Phillips and Morrow 2007).

In Puerto Rico, studies have found that age, poverty, and remoteness along with its associated service disruptions, particularly delayed or prevented access to medical care, were among the most critical factors attributed to the excess deaths and other associated challenges post-Maria. On the Island, these vulnerability factors often compounded one another, making poor elderly Puerto Ricans in remote areas one of the most vulnerable groups. Lastly, the severity of the impacts from Hurricane Maria also highlighted the Island's pre-existing physical, natural, and socioeconomic weaknesses that were exacerbated as a result (COR3 and Government of Puerto Rico 2018; Resilient Puerto Rico Advisory Commission 2018).

2.1 Old Age

Elderly individuals often represent a group with disproportionately higher vulnerability to the immediate and future effects of disasters. As shown in Figure 4-1, older males (65+) in Puerto Rico experienced prolonged elevated risk of death post-Maria while other groups approached baseline mortality risk much earlier (Andrade et al. 2018). After the hurricane, elderly Puerto Ricans have also reported greater challenges in accessing adequate shelter, services, and supplies, as well as a higher percentage of reporting mental health issues (Sago 2018; Burnette 2019; Wyss 2018a; Greenbaum 2019).

It's important to note that variations within the elderly population, such as chronological age, gender, marital status, race, education, religion, socioeconomic status, or geographic location, can greatly affect the sociological, psychological, and physiological impacts of natural disasters. However, research has found that increasing chronological age is strongly correlated with a growing constellation of significant risk factors that leads to increased differential vulnerability in the disaster setting. These factors often include physical limitations and generally more frail health conditions; higher unwillingness to evacuate; declining cognitive abilities to process hazard information; post-disaster psychological stress that impairs recovery; fewer economic resources to repair damaged homes (Ngo Ehren B. 2001; F. Norris et al. 2002; Ripley 2009; Santos-Burgoa et al. 2018).

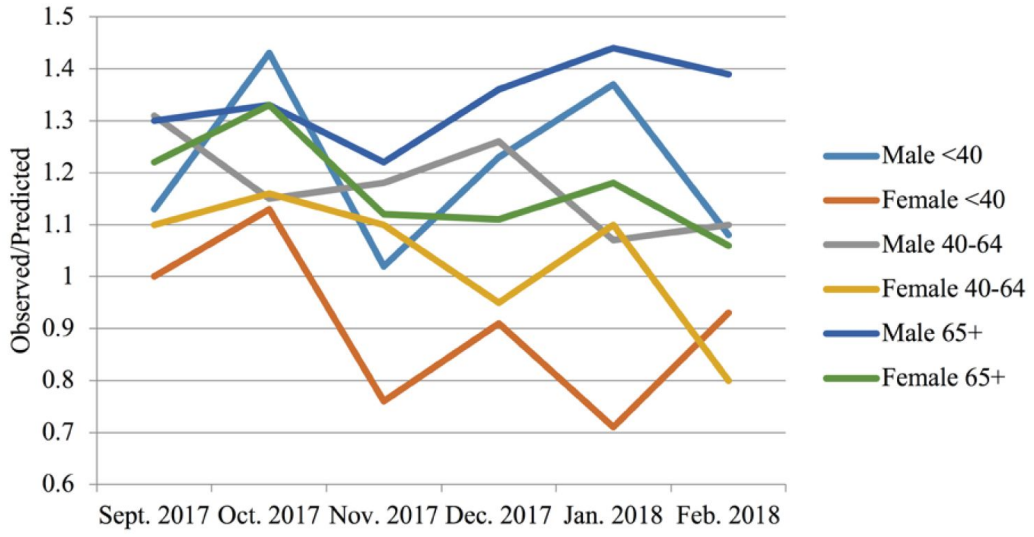


Figure 4-1. Estimated relative excess mortality from Hurricane Maria in Puerto Rico, per month, by sex and age group (Source: Andrade et al. 2018).

Given the unique social, cultural, economic, and political contexts, Puerto Rico is aging fast, leading to a growing risk of natural disasters severely impacting the health and welfare of the elderly people on the Island (Downer, Crowe, and Markides 2019). The 2019 estimate of the Puerto Rican population shows that over 20 percent are over 65 years old, and close to 40 percent is projected to age 60 years and above by 2050 (U. S. Census Bureau 2019; Salgado and Padilla 2014). As the younger generation migrates out of Puerto Rico, over 65 percent of elderly people in Puerto Rico live alone and about 20 percent live with only one other person, leaving them with tenuous caretaking support especially in the case of severe health conditions and emergencies (Salgado and Padilla 2014). However, studies have found that more than 57 percent of the Puerto Rican population, age 80 years or older, requires assistance with their activities of daily living, such as food preparation, transportation, doctor appointments, socialization with others, exercise, bathing, eating, and dressing (Fericelli 2013). Compounded with the other vulnerability factors, at least 40 percent of people age 65 and older living in Puerto Rico are below the poverty line, primarily relying on Social Security, Medicare, and public assistance as their main sources of income (Salgado and Padilla 2014). Loneliness, economic hardships, health, and lack of access to transportation were among the greatest challenges Puerto Rican elderly are confronted with, multiplying their risks in the face of disasters (Salgado and Padilla 2014; Wyss 2018a; Varney and Kane 2018).

2.2 Low Socioeconomic Status

Socioeconomic development status was another main factor in the increased mortality risk, housing challenges, disruption to services and supplies, and mental distress post-Maria. The risk of death was higher and persistent until the end of the study period for populations living in low socioeconomic development municipalities (Junta de Planificación Oficina del Gobernador 2017;

Santos-Burgoa et al. 2018; Andrade et al. 2018) (Figure 3-1 and 4-2) . A satellite-based assessment of electricity restoration efforts also showed that poor residents shouldered the longest power outages as they lived in less dense, detached housing, where electricity restoration lagged, increasing mortality and morbidity risks (Román et al. 2019).

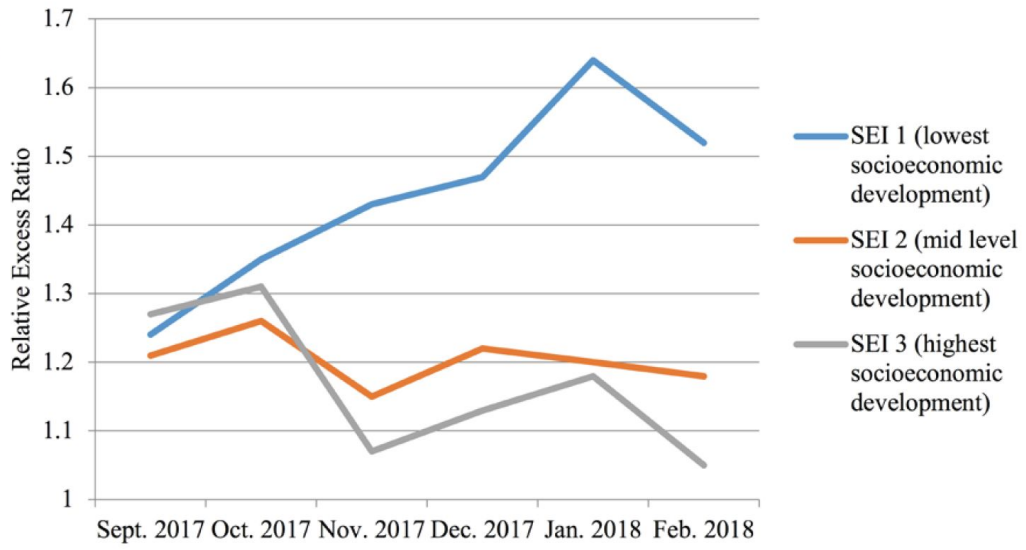


Figure 4-2. Estimated Relative Excess Mortality from Hurricane Maria in Puerto Rico, Per Month, by Socioeconomic Index Category (Andrade et al. 2018).

Studies show that socioeconomic status is a strong predictor in physical and psychological impacts pre and post disasters. Poor populations suffer the greatest losses from disasters and with limited access to public and private recovery assets. The poor are more likely to perceive hazards as risky; less likely to prepare for hazards, buy insurance, or respond to warnings; more likely to die, suffer injuries, psychological trauma, and suffer disproportionately higher material losses; and face greater barriers during recovery (Fothergill and Peek 2004; Prowse 2003).

Before Maria, Puerto Rico had been experiencing decades of economic contraction, with $70 billion in debt, an unemployment rate 2.5 times the U.S. average, and a 45 percent poverty rate at the time of the storm (Schoen 2017). The hurricane further wreaked havoc on the Island's economy, especially for workers, small business owners, and those already living in poverty, jeopardizing the viability of entire industries and communities (Hernández 2018). A year after the hurricane, more than 40 percent of the Island's population suffered a job loss, reduced hours, or lost wages from a business closure (DiJulio and Muñana 2018). For many municipalities outside of the economic bubble of San Juan, where jobs were already scarce and business slow for years, families that were already poor were left in extreme poverty. These economic challenges had been a major driver for the exodus of workers, which further limits these communities' economic opportunities while disintegrating the social fabric of communities and leaving the elderly behind.

2.3 Remoteness

Puerto Rico's rural mountain municipalities such as Jayuya, Adjuntas, and Utuado as well as the islands of Culebra and Vieques were some of the last to receive aid and restore essential services, because of their remote location and the Island's poor roads and infrastructure (Montoya 2018; Daub 2017) (Figure 4-3). Many of these areas also have the highest percentage of elderly residents and poor households as young workforces have been migrating to the mainland U.S. in pursuit of greater economic opportunities, leaving these areas on an even more difficult path to recovery (Montoya 2018). Other studies have shown that access to urban centers stratifies the economic, educational, and health status of communities in general (Weiss et al. 2018).

Figure 4-3. Heatmap of average travel time to population centers of at least 50,000 individuals using local road networks across Puerto Rico (Kishore et al. 2018).

Immediately after the hurricane, much of the aid that reached the Island could not be distributed beyond San Juan to get to the remote areas, due to the lack of fuel, availability of drivers and trucks, as well as damaged roads and bridges (Daub 2017; Gillespie, Romo, and Santana 2017; LaRocco 2017). For many rural communities, people did not see any government assistance for months (Posada 2018; Agosto-Maldonado 2018).

Studies have found a strong positive association between remoteness and the length of time without essential services (i.e. electricity, water, medical services), where 83 percent of households in the most remote category were without electricity for the entire time period (Kishore et al. 2018; Román et al. 2019; Schmidt 2018) (Figure 4-4). A disproportionate share of long-duration power failures (> 120 days) occurred in rural municipalities (41 percent of rural municipalities vs. 29 percent of urban municipalities), and in the northern and eastern districts (Román et al. 2019). Many of these rural communities had not been connected to the Island's central aqueduct system before the hurricane, relying on untested natural water sources even a year after the Hurricane (Schmidt 2018; Daub 2017). In these remote areas, the already sparse, fragile medical facilities, reliant on generators and running short of vital medications, were struggling to meet the needs of the ill, frail, and elderly patients (Hennessy-Fiske 2017; Dickerson 2017; Mazzei 2019). These service interruptions had led to high levels of public health risks and severely hampered the recovery process in the remote areas of Puerto Rico.

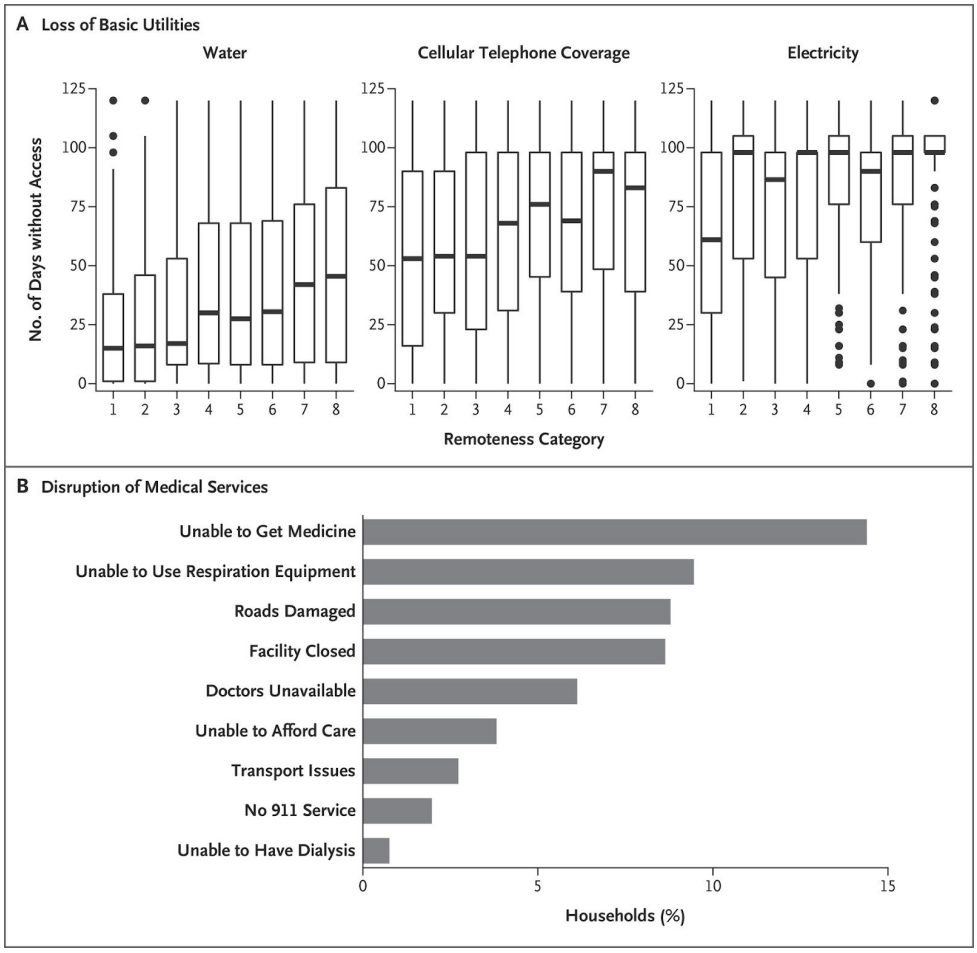


Figure 4-4. Number of days without basic services in relation to remoteness and disruption of medical services (Kishore et al. 2018).

3. Community Action and Disaster Resilience

Throughout my fieldwork in Puerto Rico, nearly every person I met shared a story of helping out after Hurricane Maria, either individually or as part of a collective effort outside of the formal disaster management arrangements. In response to the vast challenges after Maria, citizens volunteered to offer their time, knowledge, skills, and resources to help each other; while new community grassroots groups also emerged along with existing organizations to extend or pivot their services to meet people's needs after the Hurricane. These emergent citizen groups often appear during the emergency phase of disasters, while others extend to preparedness and recovery phases (Stallings and Quarantelli 1985). Post-disasters accounts from around the world and research have shown that disasters do not reduce the capacities of individuals and social structures to cope but rather present new challenges; strong social networks and structures have shown to be a driving force in addressing these challenges (Aldrich and Meyer 2015; Whittaker, McLennan, and Handmer 2015; Dynes 1994). These emergent citizens and community groups demonstrated tremendous adaptability, innovativeness, and responsiveness in the face of crisis (Dickerson 2017).

In Table 4-1, I summarize a collection of community-oriented response and recovery initiatives that I was able to either directly participate, visit the project site, or interviewed a project representative. As local governments and federal agencies struggled in the aftermath of the hurricane, these initiatives, primarily led by CBOs and NGOs, have been a major force in lifting the communities of Puerto Rico out of the devastation from Maria and preparing them for future disasters. Coming in various shapes and forms, and mobilizing citizens from across the Island, these community-oriented initiatives shed light on the importance of engaging and empowering citizens and community grassroots organizations in surviving a disaster's immediate destruction and for building long-term resilience. These initiatives can generally be grouped into the following by their objectives. The distinction between a response and recovery phase is sometimes blurred as the impact of the hurricane was prolonged especially in vulnerable communities.

1) Special services: community-led services (i.e. community kitchen, healthcare services, and supply deliveries) to provide direct assistance to those most in need within the community.

2) Community mapping and planning: efforts to document detailed community vulnerabilities and resources such as demographic information, socioeconomic data, medical history, etc., to plan for disaster response and recovery efforts.

3) Community programming: communal activities to build a sense of community, such as parties, summer camp, recreational opportunities, and others for particular demographics such as the seniors.

4) Resilience hubs: communal spaces that provide services such as energy, water, shelter, laundry in the event of an emergency, as well as host activities that help build long-term community resilience, such as training, community garden, etc.

5) Digital volunteerism: activities completed, in whole or in part, remotely via the internet that contribute either as individuals or within networks or organizations to the response effort, such as mapping damaged infrastructure, linking citizen responders with victims.

6) External direct assistance: aid in the form of financial support, supplies, repair/rebuild, temporary housing, etc. from external entities such as volunteer groups, government agencies, and philanthropic entities to help disaster response and recovery.

7) Education and training: programs to help individuals and organizations obtain, improve, and retain skills, knowledge, tools, equipment, and other resources to improve their capacities in response to disasters.

To better understand how these initiatives contribute to building disaster resilience on the Island, I conducted interviews, group interviews, and participatory observations to examine the characteristics, motivations, and processes of citizens and community organizations that responded to Hurricane Maria.

Table 4-1. A collection of initiatives led by CBOs and NGOs to help communities respond and recover after Hurricane Maria.

Entity	Type	Initiatives
COSSAO, Utuado	CBO	Free health clinic and community health workers Community mapping and information management Agriculture program for food security, employment, and education Disaster response (cleanup, distribution of supplies)
ACUTAS, Toa Baja	CBO	Community kitchen and food delivery Training and educational programs Community mapping and survey
CAM Las Carolinas, Caguas	CBO	Community kitchen and food delivery Senior center and programming Community garden, market, event space
Center for Transformation, Humacao	CBO	Resilience center equipped with solar microgrid, shelter, washing machines Community mapping and emergency planning Training and educational programs Recreation and event space
Resilient Power PR	NGO (PR)	Community solar hubs Web-based Information platforms on community vulnerability, solar energy incubation, and impact investing Advocacy for local leadership
ConnectRelief	NGO (PR)	Online platform that deploy volunteers to survey post-disaster situation and local needs to connect with resources
Para la Naturaleza	NGO (PR)	Capacity building for CBO leaders Grants for installing solar and water infrastructure
Fundación Comunitaria	NGO (PR)	Fiscal sponsorship for smaller nonprofits to receive donation Grants and capacity building for communities to strengthen capacities
Foundation for Puerto Rico	NGO (PR)	Resilience plan and increase local capacity in their decision-making processes Small business support Disaster relief funds and supplies
Hispanic Federation	NGO	Grants and capacity building for communities Disaster relief assistance
All Hands and Hearts	NGO	Repair damaged homes in communities with volunteers from around the world
Mercy Corps	NGO	Grants and capacity building for communities to establish resilience hubs with emergency response capabilities Community mapping and emergency planning
Humanitarian OpenStreetMap	NGO	An online platform where volunteers can help trace physical features based on satellite images and other geographic records
CrowdSource Rescue	NGO	An online platform that connects citizen responders with victims using crowdsourcing

3.1 Citizen Action

After Maria, people from across the Island as well as outside of Puerto Rico volunteered their time, knowledge, skills, resources in response to the aftermath of the hurricane, to fight for their own survival and to help their fellow citizens in need (Dickerson 2017; Posada 2018; Alicea 2018; Whittaker, McLennan, and Handmer 2015). Accounts from the field help illustrate the power of citizen actions in responding to a crisis and the drivers that led them to rise up to the occasion and sometimes to build long-term engagements. Their actions and engagements vary due to a variety of drivers, including their close ties with those in need, the opportunity for self-actualization, a path for empowerment, and a sense of community and hope for the future.

3.1.1 Close Bonds and Proximity as Informal Insurance

Highly valuing family, community, and social unity, many Puerto Ricans immediately went to help their families, friends, and neighbors that they share close bonds and proximity with to get through the hardships post-Maria. These stories were particularly common in remote, rural communities, where disruptions to services and supplies were delayed for extended periods. When asked what helped them to get through the difficult times after Maria, many said it was their family and faith. The strong connection — known as bonding social capital — between individuals who share similar identities, such as demographic characteristics, attitudes, and religion, is a common form of providing social support and personal assistance as a form of informal insurance in times of need (Hurlbert, Haines, and Beggs 2000; Aldrich 2012).

Although Puerto Ricans are family-oriented and try to support each other in difficult times, as young people move away from communities to urban centers and the continental U.S., many direct relatives are unwilling and/or unable to support the elderly, diminishing their social capital as a form of coping capacity (Fericelli 2013). In response to the societal shifts, especially in remote, disadvantaged areas, community members extend their support through their local church groups, neighborhoods, or CBOs to care for the elderly who have little support from their own families during crises.

For example, after Hurricane Maria, many residents from the mountainous town of Mamayes, Utuatdo, went to help their elderly neighbors and emphasized the importance of such acts of kindness in their community. One woman shared her experience helping a blind senior neighbor mark and organize things after Maria and remarked, “It was a magnificent experience.” Another woman had been helping a 92-year old woman for two years and she shared with the group, “I learned a lot from her. We are going to arrive at this point in old age. We need to learn; take care of the elderly to set examples for our children.” Another young couple, active youth leaders of their local church chapter, reported helping their 91-year old neighbor on a regular basis, and a few times to take him to the hospital. Grounded in their beliefs that the “spiritual fruits” of love, peace, and patience are central to their lives, the husband shared, “Little by little, we can make society better and encourage others to participate. When I help others, I myself become better. I feel great. It’s a beautiful experience.”

3.1.2 Self-Actualization through Volunteering

After Maria and the earthquakes in January 2020, professionals and students from the urban centers and even from outside of the Island went to the most affected areas to donate and deliver essential supplies, participate in cleaning and rebuilding, and conduct on-the-ground research and data collection. For those less affected and coming from outside of the Island, the process of helping those in need was considered an important coping mechanism and part of a self-actualization process in the face of a sweeping societal catastrophe.

CJ is a young professional and entrepreneur based in the metropolitan area of San Juan. After spending 6 years pursuing an advanced degree and professional experience in the mainland U.S., he moved back to the Island in 2017. Nine months later, Maria changed everything. Without power or the internet, he could no longer continue his technology company. After contacting a local NGO, he loaded up his jeep and went to the mountains with his wife to deliver supplies. Some of the communities they went to hadn't had water for two weeks. Along with his friends Gustavo and Luciano, they also conducted surveys and interviews across the Island to better understand the needs of communities. When asked why he took on the work, CJ replied,

> *"I had it good compared to most people. I did it because it felt good. I shouldn't sit at home and feel bad for myself. I learned lots of new skills in the process. At that time, I also experienced a major personal loss. The hurricane was like a nuke. Bringing water bottles to those in need gave me something to do and I felt like I made a small impact."*

In July 2019, I joined 60 other volunteers in Yabucoa for a week as part of a volunteer-powered disaster relief program to repair damaged homes with the organization All Hands and Hearts. These volunteers, largely young people who traveled to the Island from around the world, stayed in the camp sharing bunk beds and simple meals and worked hard, long days for weeks up to many months. Through my conversations with the volunteers to the staff, almost everyone came with the idea to help the disaster victims but left with realizations that they were the ones being helped as they gained new perspectives in the process. Many expressed profound gratitude in finding new meaning through forming connections with fellow volunteers and homeowners they had worked with, learning brand new skills, as well as being able to help someone regain hope for the future.

Francisco, a young social science researcher from the University of Puerto Rico and experienced community organizer, shared with me his secrets of effectively empowering and engaging volunteers. Francisco relied on community volunteers to help run the Center for Transformation, a community center in Humacao that was established after Maria in response to the community's need for emergency facilities such as power, shelter, and laundry services as well as a communal space for gathering and learning. He told me,

> *"I was working with over 50 volunteers of all ages and professions at the center. It's important to recognize that we can't treat them all the same. The high schoolers, university students, and*

the seniors of the community are very different. Give them interesting tasks to do. Let them choose. If they don't know how to; it's ok; teach them. Give them the spotlight and recognition."

3.1.3 Empowering the Vulnerable through Participation

The elderly and women often face various challenges in a disaster setting. However, across the Island, the elderly and women have been the backbone in community efforts in disaster recovery. Many older adults, who no longer engage in formal employment, have been most active in community-centered projects across Puerto Rico. Studies have found that elder-led community projects not only empower the elderly but simultaneously build social bonds that contribute to community resilience to future crises (Aldrich and Kyota 2017). Normally the heads of the household, the mothers, the ones caring for others, women in Puerto Rico, who started with their efforts to care for their own families and neighbors in the wake of the hurricane, took on key leadership roles in organizing and providing support to the greater communities (Acevedo 2019).

Two years after Hurricane Maria and in the midst of a series of earthquakes in January of 2020, I spoke with a group of seniors at CAM in Las Carolinas who shared with me their challenges of living with limited support on an island prone to disasters and their engagement with CAM. Doñita, 80, lived with her husband in the *barrio* (neighborhood). One day she arrived home to find her husband had fallen. "I had to take him to the hospital in an ambulance alone. And for the days that followed, I had to be there all day. When I did get home, I'd fall asleep in front of the TV," she told me. "My daughter is also sick and my son is too busy." She then cringed with anxiety, telling me that the non-stop trembles from the earthquake these days were bringing her back to the terrors of Maria. Miguel, 86, was only able to take a break a few times a week from taking care of his spouse who had Alzheimer's. He was the only person to care for her, who needed supervision 24/7, and there was no freedom for him to do other things. Christina, 77, lamented that it was impossible for most people to use any senior facilities as the price would be completely out of reach for most people.

That was why CAM's free senior programming, aptly named *El Nuevo Amanecer* (The New Dawn), had been so indispensable for the community's elderly to be able to have each other's company and share laughter despite the hardships. Many of these participants of CAM's *Nuevo Amanecer* program, were also active volunteers at the center, as chefs who cooked at the community kitchen, artists who taught their peers and children how to make handicrafts, and chauffeurs who delivered food to those in need. During my visit, they proudly and patiently showed me all the pieces of handicrafts they made, from pottery flowers to pen holders to animal sculptures made from recycled bottles. Nothing made these *abuelitos* (grandparents) happier than seeing people loving the food they made.

However, due to the lack of public transportation, which they thought were "*malísima*" (the worst), not everyone could come to the center. When asked if they'd like visitors, everyone nodded. Sara, who had a vision impairment and could barely leave the house without help or someone giving her a lift, beamed with a smile and said, "I'd love it if they could come in the morning and stay as long as they can." They told me that it would be even more important to have someone visit them in case of an emergency such as an accident or a disaster, as they were often too nervous to even make a

phone call under such circumstances. Even though facing extreme hardships and an uncertain future, these seniors, dearly referred to as the "*jovencitos*" (the youngsters) by the younger staff at the CAM, radiated with strength and optimism.

3.1.4 Long-Term Engagement Beyond the Crisis

In the immediate aftermath of Maria and the earthquakes, many emerged as volunteers and citizen groups during the emergency phase to help with tasks such as assessing damages on the ground, delivering food and supplies, cleaning up debris, and coordinating collective actions. Most eventually returned to their normal life after some months, while some continued to engage in community-centered activities that contribute to long-term community resilience. People who continue to engage beyond the crisis phase are often closely associated with the local groups, whose mission aligns well with their own goals, values, skills, or knowledge, bringing them a deep sense of community and belonging. To engage the youth, who are the hope of communities, it is important to help bring long-term economic prospects so that they can stay in the communities where they are deeply connected with.

Having been in the construction business since 1995, David from Utuado was one of the residents that stepped forward to help with the post-Maria cleanup and continued to actively engage in COSSAO's community work as the organization looked to restore an abandoned coffee factory to become a resilient center. Whenever COSSAO needed a hand, David was a phone call away and showed up in his truck ready to help. When asked about his volunteer experience, David smiled and told me,

> *"Although we often stayed past midnight clearing the streets and working with bad machines, there were many experiences I had never felt at work before. These experiences after Maria made a huge impact on me. The most beautiful thing was to see an elderly person finally get out of the house after the road was cleared. There were many times people would ask me to get off my truck to give me a hug and blessings. For months we didn't see a government machine on the ground. Little by little, we worked hard so that everyone could get out of their house. We finally saw white lines after white lines on the roads again."*

For the community youth, many wanted to help but they were more concerned about the prospects of staying in their hometown with few jobs available at the moment. Some of the youngest at the local church chapter in Utuado, Julio (23), Deyaneira (24), and Sebastian (18) juggled work, study, family, and study. It's also a challenge for them to manage their time but they were all eager to help their communities on the weekends. They were proud of the quality of the people in their community and want to be part of the force that makes it better. For them, community programs need to first empower the community and people. Deyaneira, who is studying to be a nurse, told me, "My dream is to stay here, where I can have professional opportunities, good education for my children, and good quality of life."

3.2 Community-Based Organizations

As citizens rose up in response to the hurricane's impacts on their communities, many of them formed new CBOs to continue meeting the needs of their fellow residents and preparing for future disasters. While for existing community groups, nearly all of which reinvented themselves to meeting the new humanitarian crisis and added disaster resilience as part of their long-term agenda (Agosto-Maldonado 2018). These CBOs share similar objectives but are very much tailored to their own communities' needs and dynamics, as seen in Table 4-1. Offering essential services for their communities, the success of these CBOs is vital for building long-term community resiliency for the Island, confronted with more severe and frequent natural disasters like hurricanes.

CBOs often function as the convening force that brings community members across social groups together, playing the important role of bridging and linking social networks that connect individuals with others outside of their immediate circles and with those in positions of power (Aldrich and Meyer 2015; Aldrich 2019). Examples from Puerto Rico as well as in other post-disaster situations have shown that communities with higher levels of bridging and linking communities were more likely to recover from disasters. Communities with higher levels of bridging capital, often in the form of CBOs, are more efficient in rebuilding after disasters, as these organizations can help strengthen trust across the community and facilitate new norms about compliance and participation to get over the "collective action problem" (Aldrich 2012). In addition, communities with high levels of linking social capital, a vertical connection such as that between a community member and a disaster management agency representative, are critical to accessing resources and information that can not be found locally. This type of connection is particularly important for disadvantaged communities as even the best internally connected local communities lack the resources to respond and recover following a major disaster (Aldrich 2019).

However, many of these CBOs in Puerto Rico today, especially the new ones, often run by volunteers, struggle to sustain their mission with limited operating funds, small staff, and sporadic training opportunities (Serlin 2019). Accounts from the field suggest that the success and longevity of these CBOs in Puerto Rico often depend on the presence of individual leadership, experience and capacity, and the level of horizontal and vertical social networks (Aldrich 2012).

3.2.1 Individual Leadership as the Engine

The CBOs in Puerto Rico are often started by leaders who are well trusted and respected from within their own community in response to some widespread, salient needs people face, such as disaster response and recovery in the case of Maria (Posada 2018; Rios 2017). Similar to the other citizen groups, these CBOs are often small, relatively flat, and not very complex, with a handful of active core members supported by a larger group of members who can be mobilized for specific tasks (Whittaker, McLennan, and Handmer 2015). Most of these members are local residents who have an intimate understanding of the needs, resources, culture, and social dynamics within their community. The few core members of the CBOs play major roles in marching the organization forward, from fundraising to organizing activities to building partnerships with government officials. Rarely through paid positions, these core CBO leaders demote large blocks of time to the

group while upholding their other responsibilities such as their formal employment and caring for their own family. These leaders often have to make significant sacrifices for the communities as they deal with personal challenges and losses, especially in the wake of disasters.

Maria is one of the presidents of ACUTAS in Toa Baja, where her community suffered unimaginable losses from flooding during the hurricane, as many of the homes were built without permission in a low-lying area close to some canals. Maria recalled the harrowing scenes of floodwater swallowing people's homes in her community. With their homes damaged by floods, many had no place to shelter. At the time, accounts of violence and assaults started to spread in the community. Maria, whose house had a second story that was not covered by floodwater, invited her neighbors to stay. She described the terror she experienced every time someone would knock on her front door, worrying that burglars would break in. It was in her house as people gathered and shared the little resources, ACUTAS was formed.

For days and weeks, people had no access to power or running water, while suffering one humid day and night after another. They had no way to even take a shower or wash their clothes. There was no government assistance insight. Left with no choice, Maria, along with several other women from the community, broke into their local school, where they were able to access running water and started a community kitchen to deliver food to the hungry residents. Nearly two years after the hurricane, Maria couldn't help but start to tear up as she recounted the many nights when she took her son to help her deliver food to the community residents. "I was scared that something could happen to us. It was all dark. By the time when the shift is over, I'd turn around and look over the backseat," Maria shared with a sigh of guilt as a mother, "my son always had fallen asleep already."

3.2.2 Experience and Capacity Gap

For emergent CBOs, either newly formed or pivoting their services in response to the hurricane, as they grow, most take a trial-and-error approach in their first efforts. Most organizational leaders, many of whom had little prior experience running organizations, had reported challenges as they learned how to mobilize community members, navigate levels of political bureaucracy, manage funding partnerships, and the plethora of many challenges of running a nonprofit.

Studies have found varying degrees of capacities, knowledge, and experience with disaster management, as well as access to funding and resources across community groups on the Island (Sledge and Thomas 2019). For these emergent groups, coordination and service delivery challenges have been prevalent in response to Maria, which was severely hampered by effective information management both within the community and with outside entities. Without a reliable information system to coordinate efforts across the entities, people reported: "an enormous duplication of efforts, wasting money and resources" (Sledge and Thomas 2019)

Recognizing the need to improve disaster information, many CBOs initiated projects to map their community's needs and resources in detail, in order for them to deliver help to the right places and better plan for future disasters. For example, for over six months, the four presidents of ACUTAS went to hundreds of households to collect information about their socioeconomic status, medical

conditions, as well as needs for supplies such as food and water. They then transcribed paper surveys to notations on a large printed Google satellite basemap (Figure 4-5). For small towns in Puerto Rico like the one where ACUTAS is located, the information on Google Maps is either outdated, incorrect, or nonexistent. In Puerto Rico, the lack of a consistent mailing address system makes the project even more complex using a universal basemap like Google. House by house, they wrote down house numbers, used colored dots to indicate the presence of particular demographic groups (e.g. children, elderly, and bedridden), and corrected the wrong street and landmark names. Given the changing nature of community information, with only four people managing the information system, it became an impossible task to keep updating the paper map. When I visited ACUTAS in late August, the community leaders shared with me their attempts to update the map in preparation for the imminent landing of Hurricane Dorian, as they realized that the marked-up map was two years old and probably no longer useful. The effort was eventually abandoned due to the amount of work and lack of hands.

Figure 4-5. A community map developed by ACUTAS, Toa Baja, that uses Google Maps as a base. The staff used stickers to indicate the status of each household, added house numbers, and corrected mislabeled information, such as street names and points of interest.

Similar efforts to map community information were reported at COSSAO, CAM Las Carolinas, Center for Transformation, Yabucoa, and the 16 communities that were part of the Mercy Corps Resilience Hub project, tapping into the power of community knowledge and social networks. While in some other communities, some CBOs created their own file system to record residents' medical histories. All of these community mapping efforts were initiated and managed by CBOs as part of their

disaster resilience-building efforts, presenting opportunities to bridge the disaster information gap for citizens and communities. However, these emergent community mapping efforts have not been integrated into the formalized disaster management systems on the Island.

3.2.3 The Duality of Social Networks

The level of social networks of CBOs is a driving engine for the viability of the organization and the long-term resilience of the communities they represent, especially against the backdrop of the fast-changing political and philanthropic landscapes of post-Maria Puerto Rico. Before Hurricane Maria, Puerto Rico had rarely been on philanthropy's radar. A 2018 report estimated that funders provided more than $375 million for disaster relief for the Island, more than 60 times the amount Puerto Rico had received annually in previous years (Petrovich 2018). Nearly two thirds of the funding came from the Puerto Rican diaspora, demonstrating the power of social networks at large in the Puerto Rican community. Donors were also reported to favor local organizations while some used local foundations as intermediaries and fiscal sponsors for the newly established CBOs.

However, for local community groups, to access the funding and support has not been straightforward or easy, as the duality of social capital comes into play, where social capital sometimes can reinforce existing inequality and slow down the recovery for some of the more marginalized community groups (Acevedo 2019; Aldrich 2012). Based on my conversations with donors, NGOs, researchers, and CBO leaders, without reliable information on community needs, almost two years after the hurricane, there was not a systematic approach or clear standards for deciding how to allocate the funding and resources that so many communities were in dire need for. The primary drivers have generally been pre-existing relationships between communities or individuals with the donor or project sponsors such as large international NGOs. While donors looked to help, they were also asking for accountability, which often led them to resort to the more established organizations or communities, leaving the already disadvantaged, less connected communities and CBOs with even less support.

Additionally, throughout my conversations with community leaders, the political complications and bureaucracy with the municipalities were also reported as a major obstacle in obtaining their 501(c)(3) status as well as permits to use the public spaces to run their programs. Without the 501(c)(3) federal status, which had not been a requirement because people don't file federal taxes, local groups either had to rely on bigger, registered organizations or miss the funding opportunity. "It's essential for the government to connect to the community groups in order to break through the barriers that bureaucracy, corruption, and political agendas have built after this recent natural disaster. These have not only become a waste of funds but also created a greater division between the people and the government aid agencies," commented the Operations Director from one of the largest donors to the Island (Hispanic Federation 2019).

CHAPTER 5: THE COSSAO COMMUNITY HEALTH PROMOTER PROJECT

1. Overview of Utuado and the Impact of Maria

In the central mountainous municipality of Utuado, Puerto Rico, I conducted interviews, group interviews, and participatory observations in January 2020 in collaboration with the *Corporación de Servicios de Salud Primaria y Desarrollo Socioeconómico El Otoao (COSSAO)* (Corporation for the Health and Socioeconomic Development of Otoao), a community-based nonprofit organization that emerged as a leader in building community resilience after Hurricane Maria. This case study of COSSAO seeks to capture the strength and resourcefulness of the community in their efforts to adapt to the post-Maria reality.

The region where COSSAO is located was among the hardest-hit areas struck by Hurricane Maria (Farinas 2018). This part of the Island is exposed to an extremely high rate of landslides due to the soil type that is susceptible to impacts from heavy rainfall and flooding from hurricanes (Bessette-Kirton et al. 2019; Hernández Ayala et al. 2017)(Figure 5-1 and 5-2). One of the most remote and difficult-to-access areas, the region did not receive local assistance more than 10 days after the event, and it was 42 days before the federal government provided any aid to the residents (Milman 2017).

Figure 5-1. Damaged homes near a washed-out road in Utuado, Puerto Rico, on October 3, 2017 (Photo: Eric D. Woodall/US Coast Guard/AP).

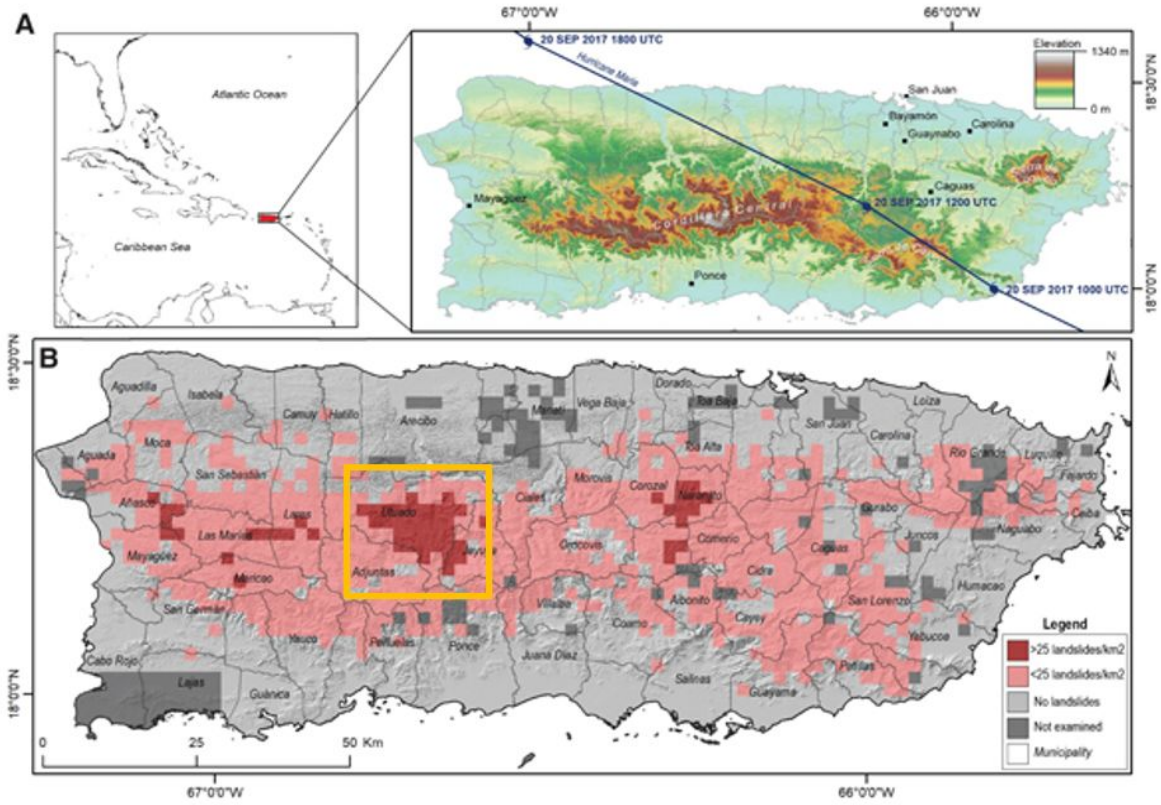


Figure 5-2. (A) Topographic map of Puerto Rico showing the storm track of Hurricane Maria. (B) Relative density of landslides mapped from the rapid classification of satellite and aerial imagery and site visits following Hurricane Maria. In the central mountainous region, Utuado suffered massive damages from landslides (Bessette-Kirton et al., 2019).

Pre-disaster conditions such as neglected infrastructures, i.e. roads, water, sewage, energy, telecommunication, and healthcare, exacerbated the damage caused by Hurricane Maria (Holladay et al. 2019). Some communities of Utuado had not had potable water or electricity for as long as 15 years. According to the 2019 census data, over 50 percent of the population in Utuado liveD under the poverty line and over 22 percent of the population were over 65 years old, presenting additional social and economic vulnerability of the region (U. S. Census Bureau 2020). Utuado was among the municipalities that suffered the highest percentage increase in crude mortality rates in the six months after Maria (Andrade et al. 2018)(Figure 3-1).

2. COSSAO Background

The effects of Hurricane Maria coupled with the long history of marginalization and lack of government support led to the transformation of COSSAO, catalyzing social change for the communities. In 2013, COSSAO was created with the idea of reviving the local economy by providing resources to small business owners. In the wake of Maria, COSSAO reinvented itself with a holistic sustainability vision to improve the socio-economic status and health of community members while building capacity for disaster resilience (COSSAO 2019). The organization's

leadership and volunteers mobilized much of their own financial and human capital and worked hard to clean up debris, stabilize infrastructure, construct a community primary healthcare center, create agricultural programs, and initiate community disaster preparedness and resiliency projects.

Tito, president of COSSAO and a native of Utuado, had been instrumental in trailblazing new paths for the organization and the communities it serves. A former college basketball athlete and an engineering graduate from the University of Puerto Rico Mayagüez, Tito is a towering figure, literally and figuratively. Gregarious and speaks with a sonorous voice, Tito is impossible to miss (Figure 5-3). Aside from COSSAO, Tito is also a husband and father to two college-age daughters and owns a gas station and a colmado (convenience store) in the town of Mameyes. Tito worked around the clock; one would likely find him either in meetings with COSSAO staff or on the phone trying to make a connection, solve a problem, or respond to a resident's need.

When Maria hit, he brought the communities together and led the disaster recovery that is still ongoing today. On the first day after the Hurricane, he walked for 12 hours through 10 miles of fallen trees and debris to town in order to get the rescue work started. Sometimes having to ration food and work with broken machines, many people from the community volunteered and worked long days for weeks to clear the roads and stabilize the infrastructure with their own hands and resources. Many of these volunteers continued to actively participate in COSSAO's various projects and initiatives.

Figure 5-3. The Community Health Promoters Project staff with the President of COSSAO (last row) in their office in January 2020. (Photo: Yiyuan Qin)

Today COSSAO provides services to over 8,000 people across 5,000 households in seven communities in the region: Frontón in Ciales, Mameyes Arriba in Jayuya, and the Caonillas communities, Don Alonso, Tetuán, and Mameyes in Utuado. As of 2019, COSSAO was running or in

the process of implementing 18 projects and initiatives across four thematic areas, including health, socioeconomic status, education, and what they call "autogestion" or self-dependence (Figure 5-4).

COSSAO is governed by a Board of Directors of 11 members. The board members are elected every two years by the residents of the *barrios* that COSSAO serves. 21 paid staff and over 50 local volunteers support various events and initiatives of the organization. In response to COSSAO's commitment to the sustainable development of the local communities, COSSAO hires exclusively from a pool of applicants from the region they serve.

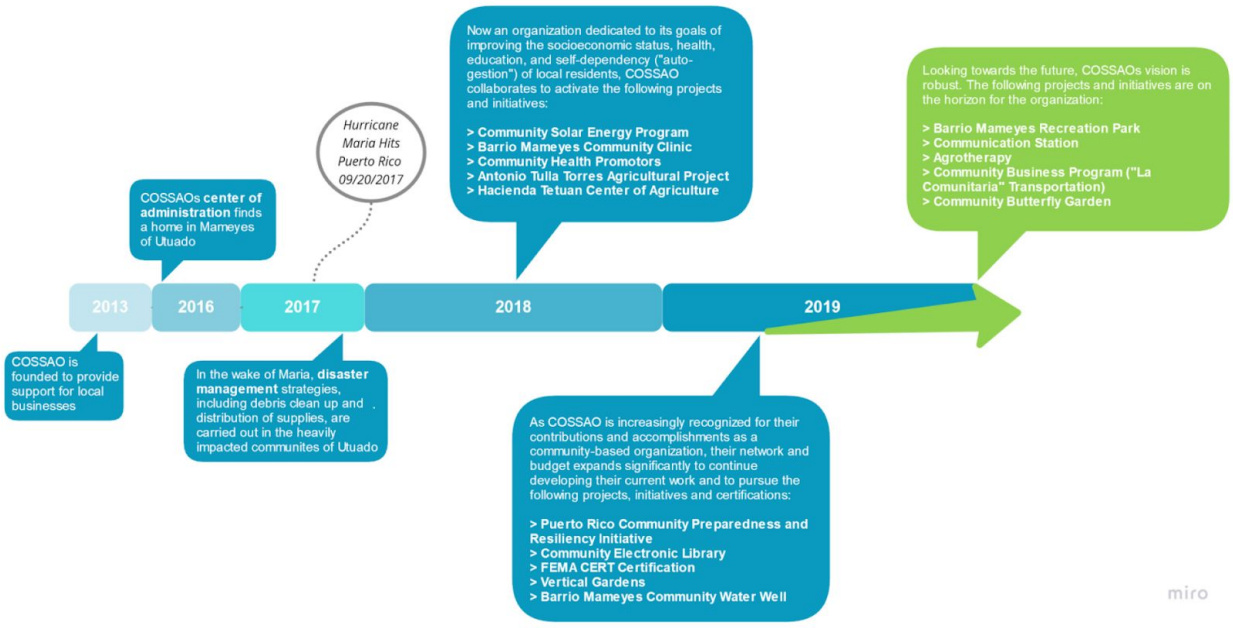


Figure 5-4. A timeline demonstrating the evolution of the projects, initiatives, and certifications along with future plans for COSSAO (COSSAO, 2019).

3. The Community Health Promoters Project

With funding and support from Heart to Heart International, global humanitarian organization, COSSAO developed a community-based primary healthcare model in 2018, which includes the *Proyecto de Promotores de Salud Comunitarios* (Community Health Promoters Project) and a primary health clinic. First of its kind in Puerto Rico, this community-based approach to healthcare has become an essential part of the community's response to the impacts of Hurricane Maria in the region, as disruptions to medical services were among the most common causes of post-hurricane deaths (Kishore et al. 2018). Before COSSAO established its community clinic in Mameyes, Utuado, people had to travel an hour or more for healthcare, even for minor issues (Allen and Peñaloza 2019). The community health clinic provides healthcare services for free to all seven *barrios*, including a pharmacy, an ambulance, primary care, pediatrics, dental care, and physical therapy.

The Community Health Promoters Project (CHP) consists of four components: public health, physical health, mental health, and community issues (Figure 5-5). The CHP is run by seven paid health promoters, one for each community, along with one supervisor and one project coordinator. With experiences as social workers, nurses, and medical technicians, the health promoters, mostly women between ages 20 and 50, all come from the communities that they serve and go through extensive training in healthcare and community participatory strategies through workshops and practical experiences (Figure 5-3).

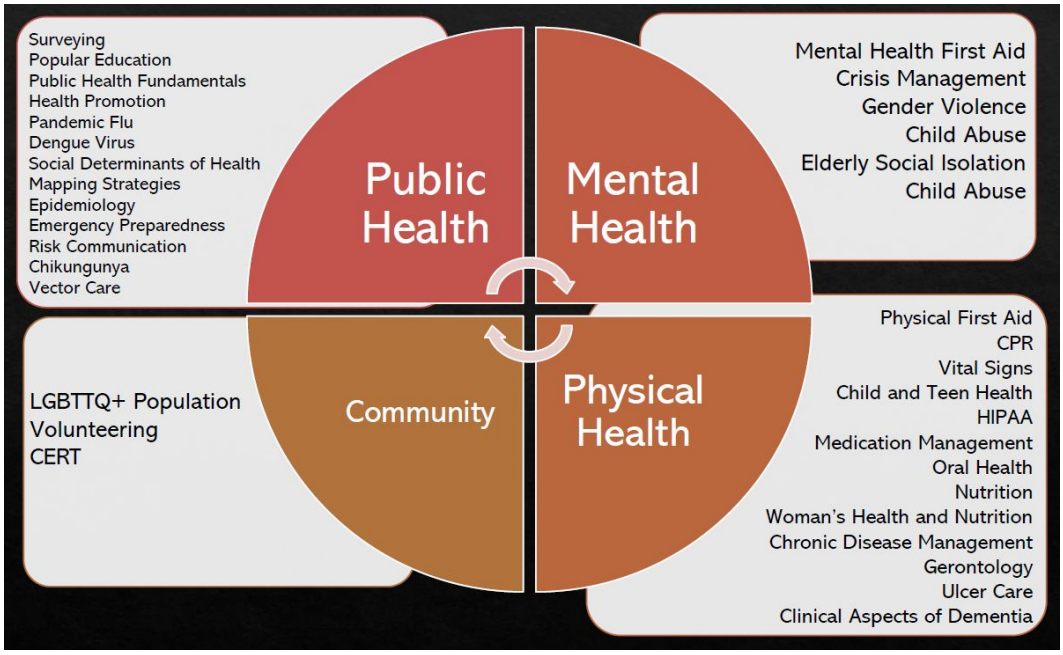


Figure 5-5. The thematic services provided by the Community Health Promoters Project of COSSAO (Heredia-Morales et al. 2019).

The health promoters survey social and health necessities, provide referrals to the community clinic or governmental agencies, distribute care packages and water filters, promote community health education and activities, and companionship to those that live alone. The health promoters work full time to serve over 5,000 households in the area and are prepared to respond to emergency situations. Since the establishment, they have delivered over 200 water filters, more than 300 care packages (food, clothes, diapers, toys, hygiene kits), and provided more than 200 referrals for physical and mental health services (Heredia-Morales et al. 2019).

3.1 Family Visits and the Roles of Community Health Workers

The primary form that the health promoters serve the communities is through family visits. For four days a week, each health promoter visits 10 to 15 homes in their designated community each day from 9 am to 3 pm. Each family visit takes around 30 minutes, but can often last significantly longer depending on the individual circumstances. For the last hours of the day and every Friday, back in the COSSAO office, they enter and manage the data they collect during the week into a computer-based system. Each health promoter has a planned route to follow and they can rotate

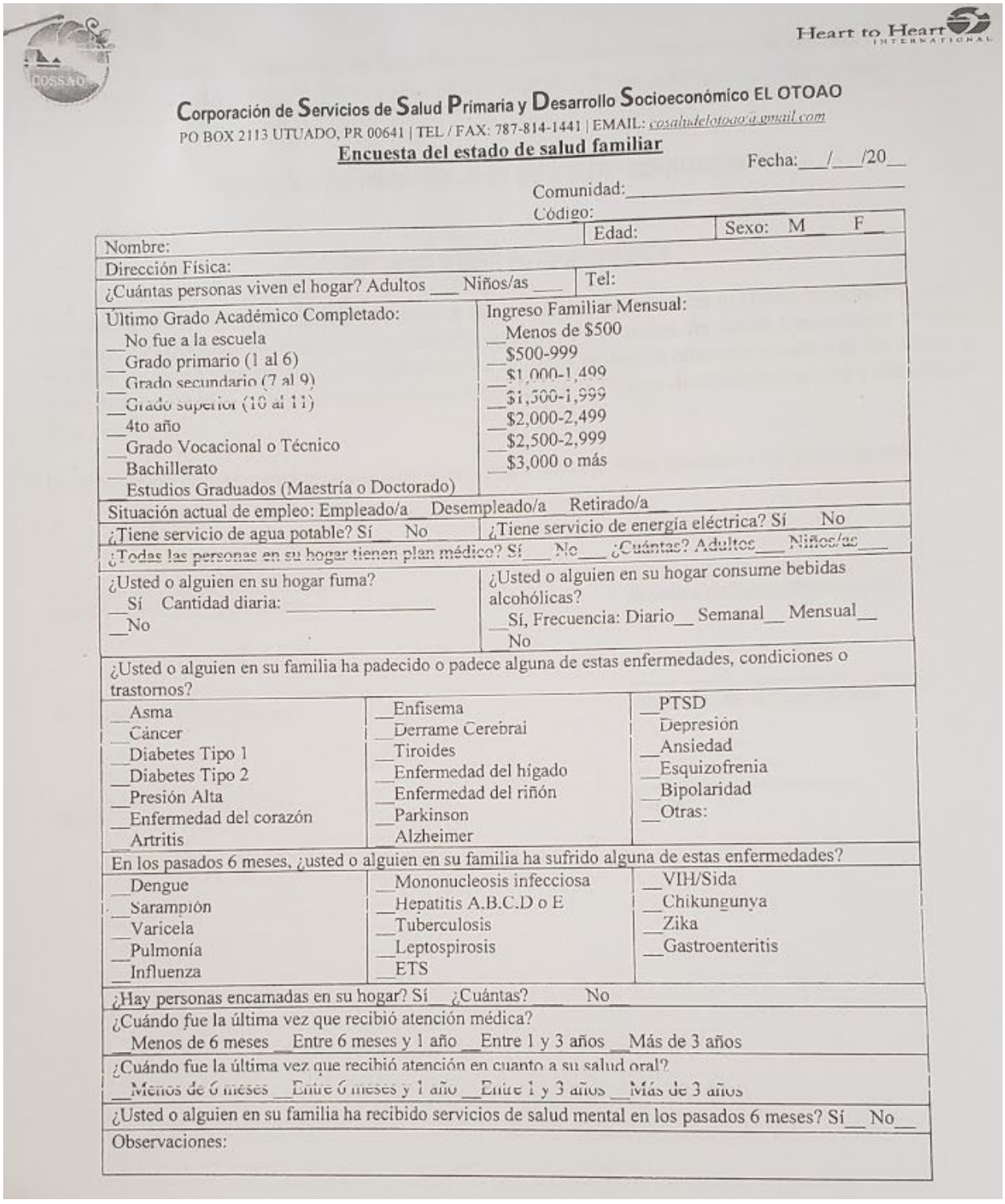
through all the households in their community in about six weeks. For households that require more intensive care, they make a note to check up on those more frequently. Overall, their work routine can vary considerably week by week, when extraordinary circumstances arise in the community such as accidents or serious health issues, or when other organization-wide events require their attention such as training with visiting medical doctors.

When health promoters go on family visits, there are two main objectives: the first is to register new cases and gather socio-economic and health information about the family members; and the second is to carry out health and wellness checkups, information updates, and other missions the project is working on, such as recording emergency needs post disasters. During my research, I took part in eight family visits as an observer with two different health promoters accompanied by the program supervisor on two different days. For privacy concerns, the names of community residents were omitted in the case study.

On a typical day, the health promoter checks in at the COSSAO office in Mameyes around 8 am, picks up her paperwork (forms, maps, and other promotional materials), changes into the health promoter uniform, and promptly gets on the road in her personal vehicle to go through the day's route in her community. Throughout the day, a health promoter plays a multiplicity of essential roles for the families and community they support, including community information surveyor, primary care provider, educator, companion, and many more. For the six hours on the road, she has a plan of the families she will visit, marked on a hand-drawn map and a checklist. When she arrives at a family's house and as soon as she parks her car, she announces her arrival — a health promoter from COSSAO — loud and clear and waits for the family to respond.

When it's a new family, they often have already heard of COSSAO from their neighbors and friends and are happy to be part of this free community service. The health promoter provides educational materials, explains the different healthcare services COSSAO provides, walks the family through the forms and confidentiality agreement, and fills the form by hand (Figure 5-6). Each family shares one form and is given a code number for confidentiality. The form documents the socio-economic information of the head of the household, such as income, education level, access to essential services, as well as health conditions of each family member, including vitals, illness, and access to medical care.

If it's a family that she has visited before, they are often already waiting for her arrival. They greet the health promoter warmly and catch her up on the latest family news and neighborhood happenings. This is often how health promoters find out about the arrival of new families, the departure of residents, and other information that could help them better understand the community's needs. The family brings coffee and treats as she sits down to check in on their current health concerns, particularly if they have a member that needs special care, such as an elderly, a bedridden person, or others with mental or physical disabilities. She visits these families on a more regular basis.



Heart to Heart INTERNATIONAL

Corporación de Servicios de Salud Primaria y Desarrollo Socioeconómico EL OTOAO

PO BOX 2113 UTUADO, PR 00641 | TEL / FAX: 787-814-1441 | EMAIL: cosaludelotoao@gmail.com

Encuesta del estado de salud familiar

Fecha:___/___/20__

Comunidad:_____

Código:

Nombre:	Edad:	Sexo: M__ F__
Dirección Física:		
¿Cuántas personas viven el hogar? Adultos ___ Niños/as ___	Tel:	

Último Grado Académico Completado: __No fue a la escuela __Grado primario (1 al 6) __Grado secundario (7 al 9) __Grado superior (10 al 11) __4to año __Grado Vocacional o Técnico __Bachillerato __Estudios Graduados (Maestría o Doctorado)	Ingreso Familiar Mensual: __Menos de $500 __$500-999 __$1,000-1,499 __$1,500-1,999 __$2,000-2,499 __$2,500-2,999 __$3,000 o más
Situación actual de empleo: Empleado/a Desempleado/a Retirado/a	
¿Tiene servicio de agua potable? Sí No	¿Tiene servicio de energía eléctrica? Sí No
¿Todas las personas en su hogar tienen plan médico? Sí___ No___ ¿Cuántas? Adultos___ Niños/as___	
¿Usted o alguien en su hogar fuma? __Sí Cantidad diaria: _____ __No	¿Usted o alguien en su hogar consume bebidas alcohólicas? __Sí, Frecuencia: Diario__ Semanal__ Mensual__ __No

¿Usted o alguien en su familia ha padecido o padece alguna de estas enfermedades, condiciones o trastornos?

__Asma	__Enfisema	__PTSD
__Cáncer	__Derrame Cerebral	__Depresión
__Diabetes Tipo 1	__Tiroides	__Ansiedad
__Diabetes Tipo 2	__Enfermedad del hígado	__Esquizofrenia
__Presión Alta	__Enfermedad del riñón	__Bipolaridad
__Enfermedad del corazón	__Parkinson	__Otras:
__Artritis	__Alzheimer	

En los pasados 6 meses, ¿usted o alguien en su familia ha sufrido alguna de estas enfermedades?

__Dengue	__Mononucleosis infecciosa	__VIH/Sida
__Sarampión	__Hepatitis A,B,C,D o E	__Chikungunya
__Varicela	__Tuberculosis	__Zika
__Pulmonía	__Leptospirosis	__Gastroenteritis
__Influenza	__ETS	

¿Hay personas encamadas en su hogar? Sí__ ¿Cuántas?___ No__

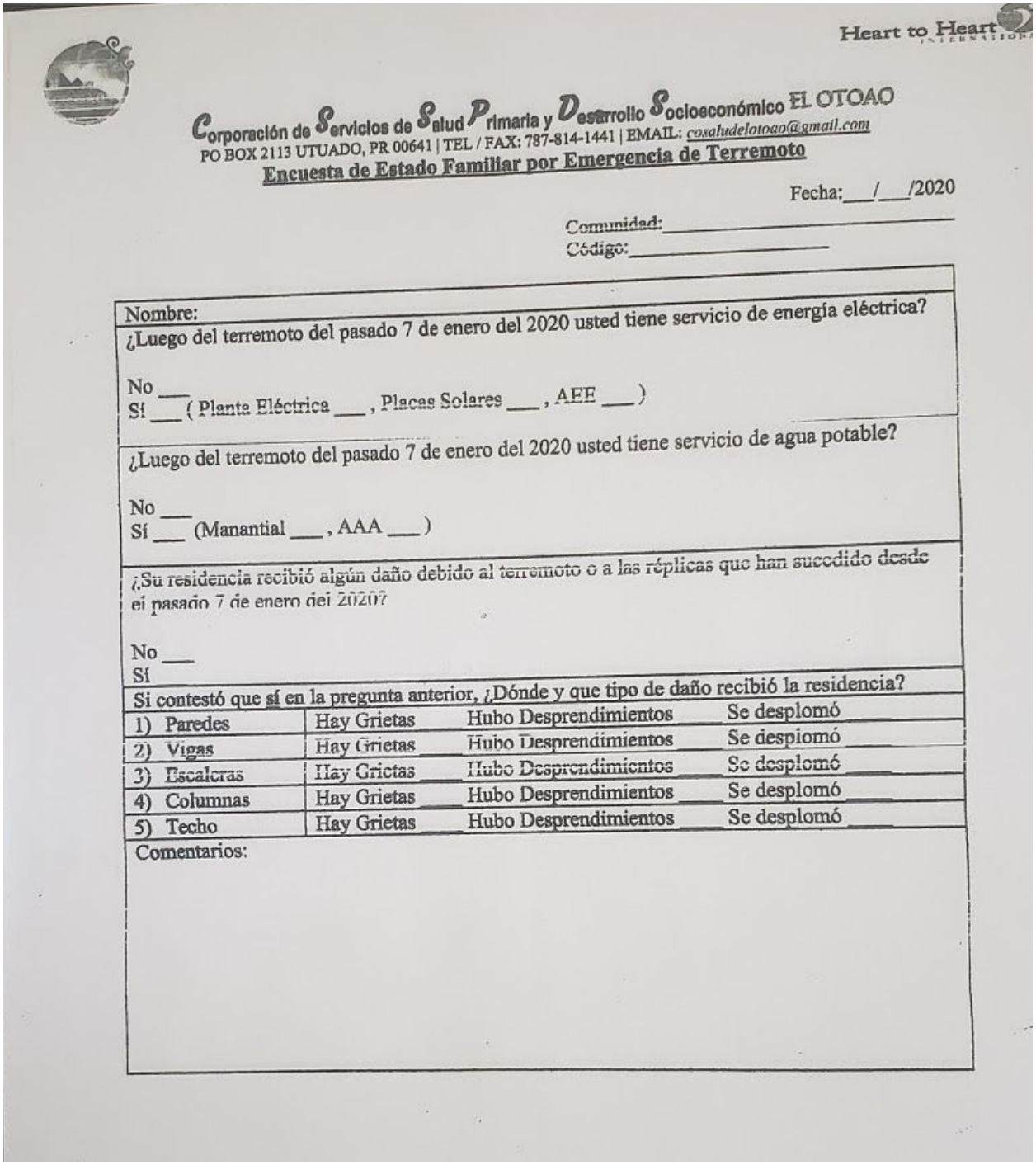
¿Cuándo fue la última vez que recibió atención médica?
__Menos de 6 meses __Entre 6 meses y 1 año __Entre 1 y 3 años __Más de 3 años

¿Cuándo fue la última vez que recibió atención en cuanto a su salud oral?
__Menos de 6 meses __Entre 6 meses y 1 año __Entre 1 y 3 años __Más de 3 años

¿Usted o alguien en su familia ha recibido servicios de salud mental en los pasados 6 meses? Sí__ No__

Observaciones:

Figure 5-6. The Community Health Promoter Project family information registration form page 1: socio-economic information, access to essential services, and health condition of the head of the household.



Heart to Heart International

Corporación de Servicios de Salud Primaria y Desarrollo Socioeconómico EL OTOAO
PO BOX 2113 UTUADO, PR 00641 | TEL / FAX: 787-814-1441 | EMAIL: cosaludelotoao@gmail.com

Encuesta de Estado Familiar por Emergencia de Terremoto

Fecha: ___/___/2020

Comunidad: _____

Código: _____

Nombre:

¿Luego del terremoto del pasado 7 de enero del 2020 usted tiene servicio de energía eléctrica?

No ___
Sí ___ (Planta Eléctrica ___ , Placas Solares ___ , AEE ___)

¿Luego del terremoto del pasado 7 de enero del 2020 usted tiene servicio de agua potable?

No ___
Sí ___ (Manantial ___ , AAA ___)

¿Su residencia recibió algún daño debido al terremoto o a las réplicas que han sucedido desde el pasado 7 de enero del 2020?

No ___
Sí

Si contestó que **sí** en la pregunta anterior, ¿Dónde y que tipo de daño recibió la residencia?

1) Paredes	Hay Grietas	Hubo Desprendimientos	Se desplomó
2) Vigas	Hay Grietas	Hubo Desprendimientos	Se desplomó
3) Escaleras	Hay Grietas	Hubo Desprendimientos	Se desplomó
4) Columnas	Hay Grietas	Hubo Desprendimientos	Se desplomó
5) Techo	Hay Grietas	Hubo Desprendimientos	Se desplomó

Comentarios:

Figure 5-7. The Community Health Promoter Project family status survey on essential services and structural damage after the earthquakes in January 2020.

If there are no concerns at the moment, she asks a member of the family to sign off on her registration sheet of the day. If there are new health issues within the family, she takes detailed documentation on their family registration form. Depending on the urgency and gravity of the issue, she either sends a medical technician to the house or makes a referral.

During extraordinary circumstances, such as when a disaster or emergency happens, the health promoters survey the status of the family and if they have any outstanding needs such as food or water due to the disaster. For example, after the earthquakes in January 2020, COSSAO created a new form for health promoters to record any structural damages and disruption to essential services in the homes they visit (Figure 5-7).

In addition to serving as the community's bridge to appropriate healthcare, the health promoters also serve as a confidante and companion, especially to those that have tenuous familial or social support. For example, we visited a 94-year-old veteran and retired carpenter and school bus driver of his community. He lived in a one-bedroom house by himself. He had many children but no one visited or took care of him. He had no formal income and lived on food given by his neighbors, nor could he drive anymore. COSSAO health promoter Rose was the only one that came to check on his health every few weeks. He brightened up when we arrived at his house and offered us all he had in his fridge at the time. Rose patiently listened to him tell her the same stories from his youth every time she came to visit. Based on their interactions, Rose believed that he was likely suffering from Alzheimer but there was no access to formal diagnosis for appropriate care in the area at the time.

The health promoters also play an important support role for the families' caregivers, which is often carried out by women, who experience greater levels of depression, frustration, and stress, compounded by the physical strain of caregiving (Family Caregiver Alliance 2006). Of the eight families we visited, there were three with individuals whose mobility was challenged due to old age or illness, and one family had young children. Two of these families only had one caregiver: one elderly woman in her 70s to her 90-year-old mother who was bedridden and deaf, and one wife to her 80-year-old husband who suffered from Alzheimer's and relied on a wheelchair due to knee problems. Both caregivers shared stories of taxing, repetitive work and its strain on their bodies and minds. It was especially hard for them during the time of earthquakes when the patients needed to be moved outside of the house on short notice for safety reasons. The health promoter's presence was an important channel for them to find solace and support.

All the health promoters at COSSAO are from the communities they serve. With the trust they have from communities and their knowledge of the area, in the face of community traumas, the health promoters help bring the community together in solidarity and shared grieving. During one of our family visits, a mother of three young children, who recently joined the COSSAO program, shared with us the suicide of her neighbor, also a mother of two young children, a few days before. The event was a shock to her as she described the event and her worries for the children left behind. The health promoters stayed with her as the woman showed them a memorial video that the community put on social media. Before leaving for the next family, the health promoters made sure that the woman knew how to get in touch with them if help was needed. The health promoters

shared with me another story of a dynamic young woman in the community who was diagnosed with cancer. The health promoters not only had been helping take care of the woman, but they also helped promote a fundraiser and group on social media to bring the communities to show their support as she battled cancer.

Lastly, the health promoters, as part of the organization's overall mission to support community members, help families that are struggling economically with information and resources through COSSAO. Through the health promoters, COSSAO learned about the situation of an elderly woman in her 70s, who lived with six adult children all had some level of developmental disabilities. They all crammed in a small house and had no formal income. The organization fundraised for the family, and with the help of volunteers, they built separate rooms for the family to live in.

As frontline public health workers who serve as a trusted bridge, community health workers are the integral link that connects disenfranchised and medically underserved populations to the health and social systems. They not only provide primary physical and mental health services, but they also help individuals, families, groups, and communities develop their capacity in understanding their health conditions and lifestyle choices, facilitate communication with the healthcare system, provide culturally appropriate health education, and bridge access to resources and information, health insurance, quality care, and health information. As a result of the direct interaction and connection — linguistic, socio-economic, cultural, and experiential — community health workers play a key role in advocating for community needs while collecting data and relaying information to other stakeholders in the healthcare system to inform policy change and development (Pérez and Martinez 2008; Witmer et al. 1995).

During one of the lunch breaks, I asked the project supervisor Betzaida Marengo how they selected the health promoters, she replied, "Empathy. That's the most important thing and how we are able to do our work. We want to help our communities, but we don't always have sufficient resources to provide them with what we need. When it gets too hard, we cry with the family and we support each other."

3.2 Community Information Management

Through these family visits, over the past two years, the health promoters have mapped 100 percent of the communities they serve and created databases of community infrastructure (homes, businesses, churches, and other points of interest) and socio-economic and health information of the residents. The objective of the databases is to serve as a road map to direct COSSAO staff to respond in case of an emergency and distribute resources to the families with the greatest needs.

In most parts of Puerto Rico, communities outside of the major urban areas are not adequately mapped in most commonly used digital mapping platforms such as Google Maps. Residences, smaller roads, and other points of interest are often missing entirely or mislabeled on these platforms. The health promoters had created detailed A1-sized (23.4 by 33.1 inches) hand-drawn maps of each of the communities they serve (Figure 5-8). For each community, they had also created letter-sized section maps and checklists of families (8.5 by 11 inches) (Figure 5-9) for ease

of use on family visits. These maps include residences, points of interest, and roads. Each house is color-coded to indicate its status (elderly, disability, summer house, vacant, etc) and labeled with the name of the head of the household and code number used in the family registration forms. Over the years, the health promoters developed iterations of the maps, improving its accuracy and sophistication (Figure 5-10). When minor changes were needed, i.e. families moving away, they used white tapes and covered the old features with new color and labels. When maps and checklists wore out, they often had to make new ones from scratch.

Figure 5-8. The Community Health Promoter Project map for one of the communities they serve (above) and close-up of a section (below). The map includes roads, houses, and other points of interest. The houses are color-coded for its use and labeled with the name of the head of the household and code referenced in the family registration forms.

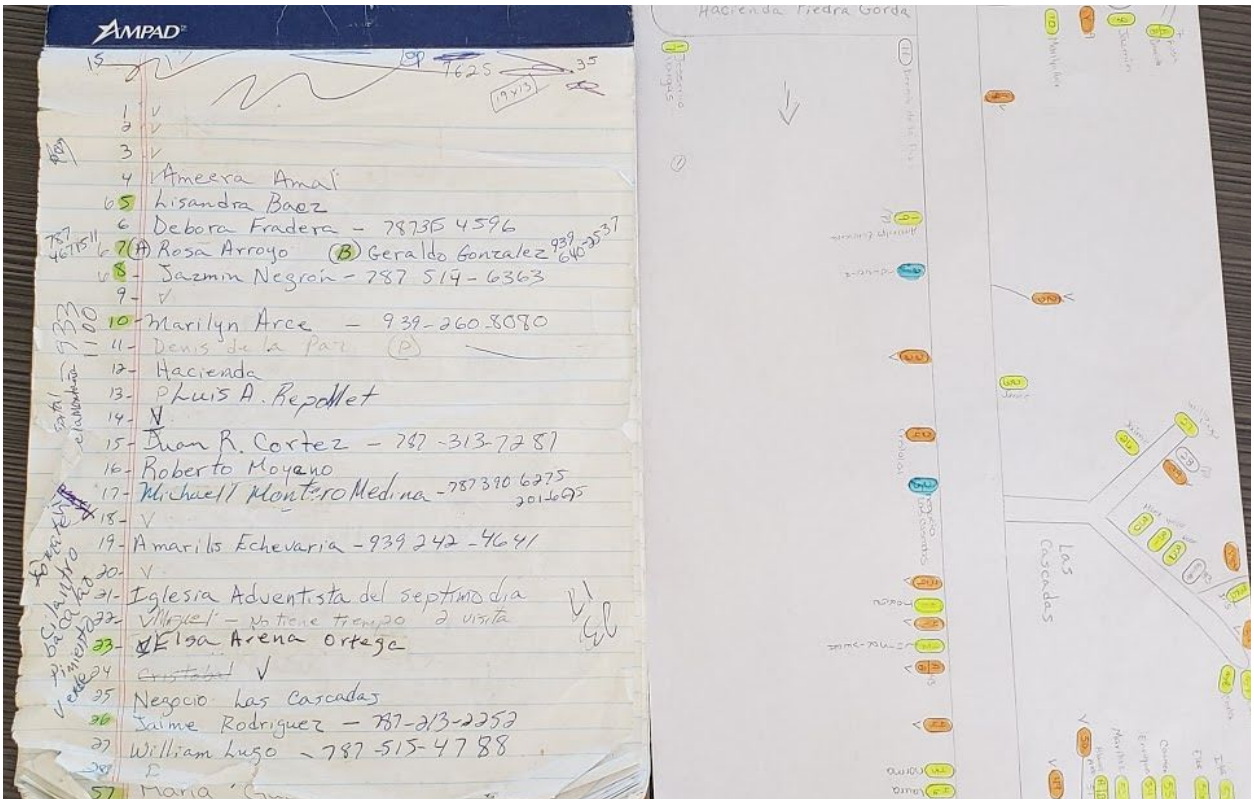


Figure 5-9. A checklist and section of a community map used by one of the community health promoters at COSSAO.

Figure 5-10. The Community Health Promoter Project maps have gone through many iterations.

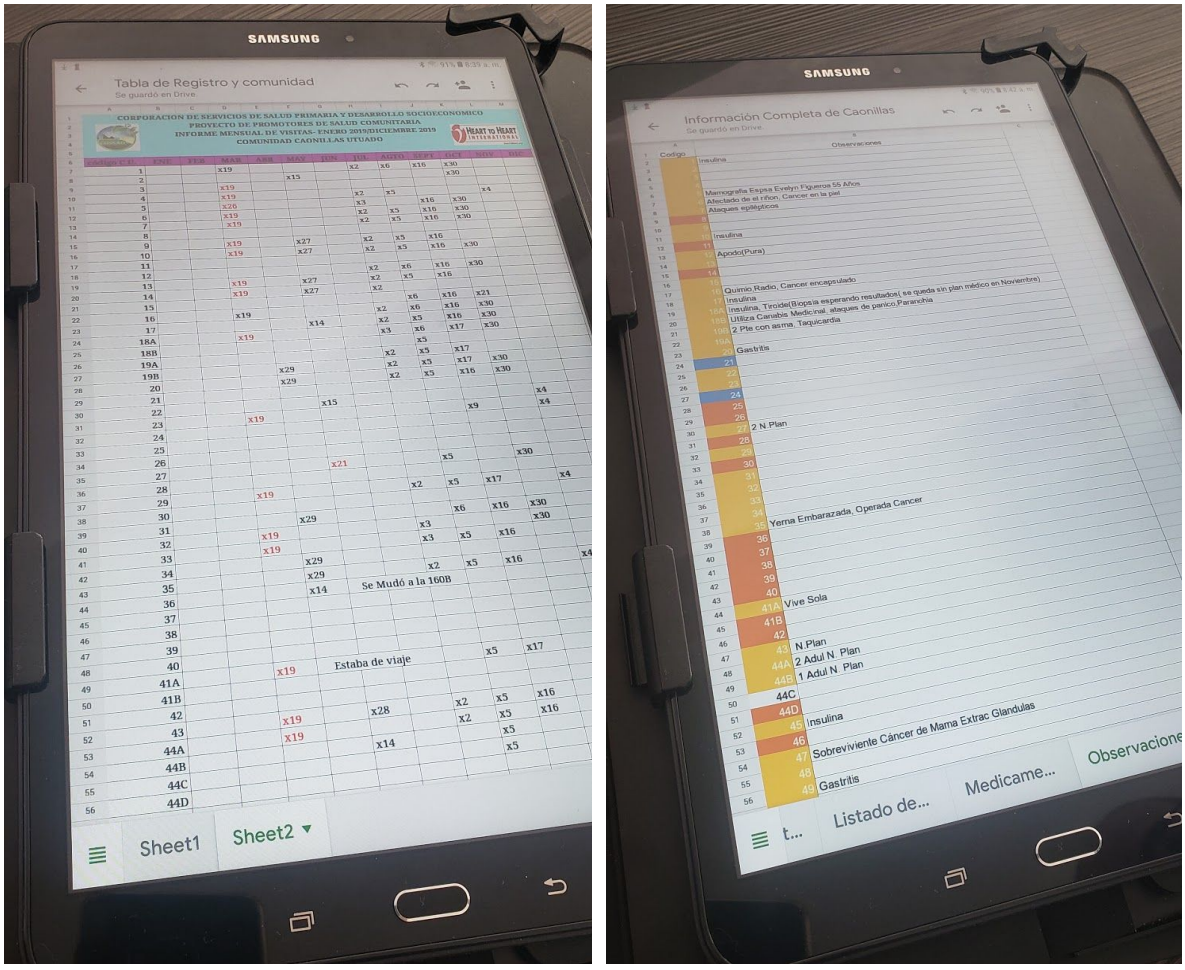


Figure 5-11. The Community Health Promoter Project database is built on Google Sheets that include both quantitative and qualitative information.

In many rural, mountainous regions of Puerto Rico, cell phone and internet services are spotty, the weather unpredictable, and roads steep, windy, and deteriorated. Instead of using the Samsung tablets provided by donors, the health promoters all preferred paper forms and maps during their family visits to avoid technical glitches and damages to the devices. At the end of the day and on Fridays, they dedicated extra time in the office and took turns to use the few computers or tablets to enter information they'd collected on paper forms into a Google-Sheet-based database (Figure 5-11). Some health promoters considered the current system relatively complicated, "It takes work and training to get used to it."

After two years of hard work, COSSAO's first-of-its-kind community mapping project in Puerto Rico as part of the CHP clearly demonstrates the value of collecting and managing the unique and diverse needs and capacities of the community residents in order to help the organization as well as external entities to better engage individuals and plan for the future. At the time of the visit, COSSAO was exploring possibilities of transferring its data collection process on mobile via an application and working with mapping experts to create digital maps of the community. The health

promoters were excited about the possibility of streamlining their data collection and entry, as they were always ready to innovate and improve.

Figure 5-12. Summary Statistics from COSSAO health promoter project shared at a conference (Heredia-Morales et al. 2019).

The project coordinator, Manuel, a University of Puerto Rico Master of Public Health Graduate, had been leading the management, analysis, and communication of the database and presenting the results at conferences and donor meetings (Figure 5-12). Through these data-driven insights, COSSAO was able to chart clear goals for service delivery, confident that they are what the community wants. The organization had also been successful in securing funding from private, state, and institutional donors by clearly demonstrating the needs and capacities of the community and the organization's commitment to providing the services their people asked for. COSSAO's success was also a result of the organization's active partnerships with universities, FEMA, local government agencies, as well as the private sector. Thanks to Tito's tireless calling and meeting people all over the Island, COSSAO had quickly grown to be one of the most well-known CBOs.

4. COSSAO's Challenges and Opportunities

COSSAO's transformation after Maria is an example of how passionate leaders, broad social networks, and meaningful engagement with local volunteers and residents can help communities rise up after disasters and set them on a path to a better future.

Despite the growth and success the organization has experienced, COSSAO and the communities they serve are not immune to many of the challenges others face on the Island. Although there was a healthy group of dedicated staff at COSSAO, with 18 projects and many more in the plan, there was little slack and everyone was stretched thin (Figure 5-x). During my stay, with only a few days before his younger daughter's departure to return to college, Tito was called to the clinic around 7 in the morning and rarely returned home before 10 at night.

For the seven health promoters who care for 5,000 households, they thought a six-week rotation was too long and they often had to rush. They often felt helpless when they couldn't help the residents they took care of with the limited resources and time they had. Even though COSSAO worked hard to create these paid positions, many thought the salaries were too low.

Although COSSAO and the community had worked tirelessly to improve the condition, many people in the region were still in a vulnerable position after decades of disenfranchisement. Many didn't work and relied on the government to survive, while the youth felt conflicted about whether they could stay and find a good job. However, people shared with me that they cared deeply about their community and the recent disasters had brought them together. At the time of my visit, Puerto Rico was experiencing chronic earthquakes. During my group interview with the local church group, Tito shared:

> *"We didn't have anything after Maria. We didn't have any technology that worked. We were speaking with our neighbors. Children were playing and sharing. Human contact arrived at a point that we hadn't experienced. When there is a crisis, everyone cares, and everything matters. But when time is normal, we don't seem to care as much. We are now in a moment of sharing and it is time to create a more caring and humble community, where neighbors care for each other and serve the elders."*

On my last day in the community, Tito took me to an abandoned coffee factory on top of the mountains. He told me that he was working with a university professor to secure funding to turn this place into a sustainable lodge and a restaurant as part of the agritourism program to help generate income and jobs for the region. The center would be equipped with solar power and water systems that can be used as a shelter in case of an emergency. He could barely contain his excitement as he led me through the building and vividly described how every part of the facility would be used as if the project was already completed. Before he went to take another phone call, he laughed, "Well, I don't always know the rules. I just go and figure it out as we go."

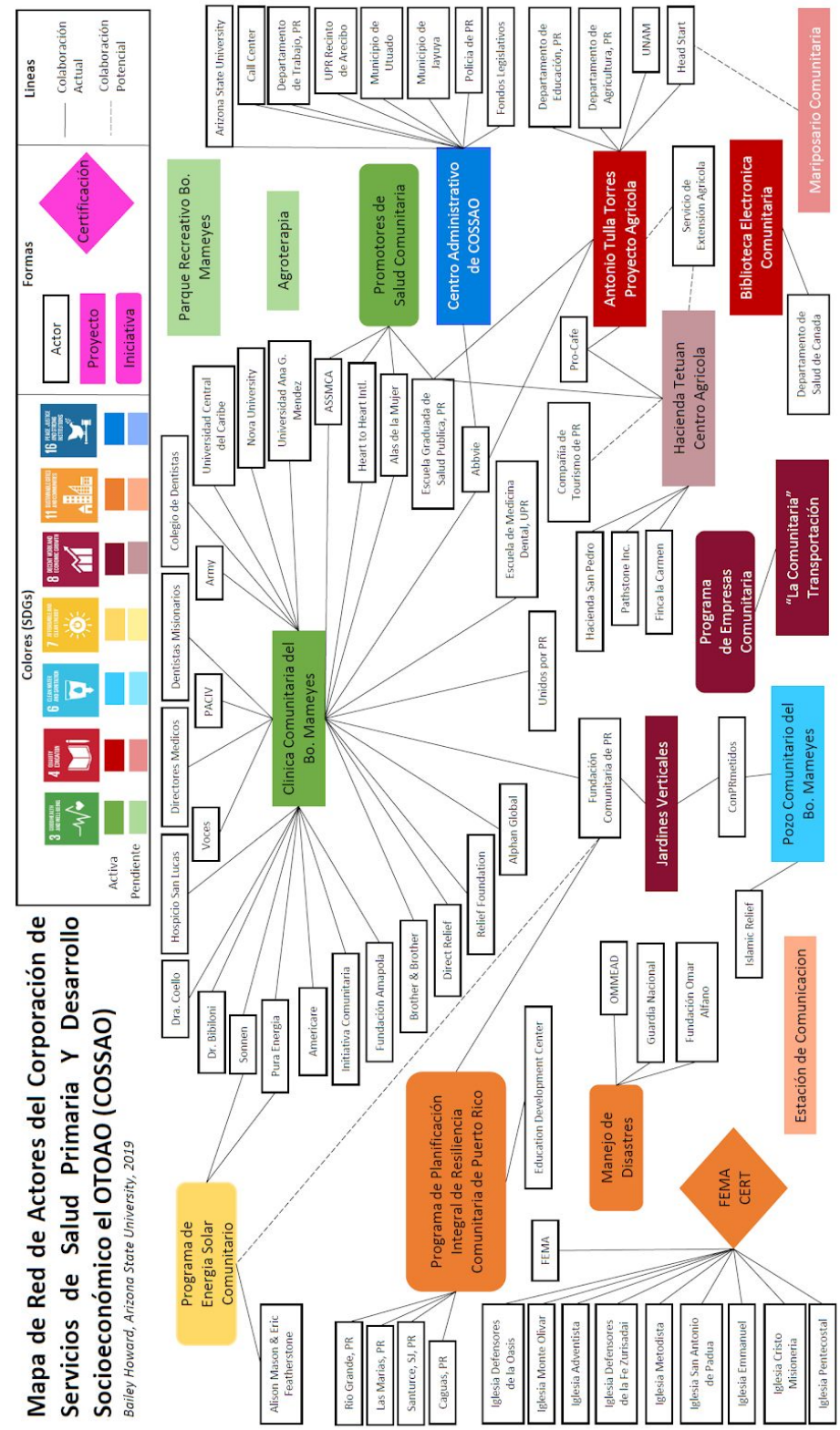


Figure #. Stakeholder map of COSSAO's project network (Howard 2019).

CHAPTER 6: DESIGN FOR RESILIENCE THROUGH COMMUNITY MAPPING

1. Design Opportunity

As Puerto Rico prepares for more severe and frequent disasters, this thesis shows that there is a clear gap in the current disaster management system in engaging and empowering citizens and communities towards a more resilient future. The time, knowledge, skills, and resources from citizens and community groups have proven to be an immense resource for disaster management. Given their adaptability, innovativeness, and responsiveness, citizen groups are driven to act in times of crisis. It is vital that disaster management and aid agencies are prepared to cooperate with them and coordinate together to ensure effective response and minimize harm.

As seen in post-Maria Puerto Rico, the response and recovery efforts were troubled by challenges in disaster information and knowledge management, particularly around coordination of service delivery and allocation of funding and resources. Recognizing the need to better manage information about their vulnerabilities and resources, community groups from around the Island have undertaken initiatives to collect detailed information to help plan for future disasters. As shown in Puerto Rico and other contexts, there are functional, structural, and social barriers that prevent the inclusion of local information and knowledge into the official channels of disaster management. To bridge these barriers between communities and disaster management and aid agencies, these community mapping efforts, such as the one through COSSAO's Health Promoters Project, have demonstrated potential as boundary objects to promote cross-border collaboration and enhance disaster resilience of the Island.

Drawing from primary and secondary research findings, I propose design recommendations for creating a more inclusive and effective disaster information and knowledge systems that bring together key actors and build on their existing capacities and meet the identified needs. These recommendations are informed by the set of premises from literature review and guided by established disaster management frameworks. I primarily use the Sphere standards and FEMA's Whole Community Approach as part of the National Planning Frameworks, which are widely recognized and used by international and U.S. entities in relevant fields.

The design recommendations focus on improving disaster resilience for individuals and communities that share one or more aspects of vulnerabilities identified in the previous chapter, including old age, poor health, low wealth, and low accessibility. Having emerged from a human-centered, system-minded research process, these recommendations do not intend to be comprehensive nor definitive, but to invite scholars and practitioners alike to explore some potential points of intervention to improve community resilience for places like Puerto Rico.

2. Guiding Principles

The Sphere was created in 1997 by a group of humanitarian NGOs and the Red Cross and Red Crescent Movement with the aim to improve the quality of humanitarian responses and support accountability across (Sphere Association 2018). It is one of the most widely referenced humanitarian resources globally. The Sphere is based on two core beliefs:

- *People affected by disaster or conflict have the right to life with dignity and, therefore, the right to assistance; and*
- *All possible steps should be taken to alleviate human suffering arising out of disaster or conflict;*

And four Protection Principles that apply to all humanitarian action and all humanitarian actors:

- *Enhance the safety, dignity and rights of people, and avoid exposing them to harm;*
- *Ensure people's access to assistance according to need and without discrimination;*
- *Assist people to recover from the physical and psychological effects of threatened or actual violence, coercion or deliberate deprivation; and*
- *Help people claim their rights.*

The Sphere recognizes that the state or other authorities have the duty to ensure people's security and safety, while humanitarian actors encourage and persuade the authorities to fulfill their responsibilities and, if they fail to do so, assist people in dealing with the consequences.

In the U.S., FEMA's National Planning Frameworks provide fundamental doctrine for achieving the National Preparedness Goal using five core capacities: Prevention, Protection, Mitigation, Response, and Recovery (U.S. Department of Homeland Security 2015). The goal is stated as "A secure and resilient Nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk."

Recent large scale disasters have shown that disaster management requires more resources and support to achieve the preparedness goal than any jurisdiction or agency can provide alone. In 2011, as part of the National Planning Frameworks, FEMA published *Whole Community Approach to Emergency Management: Principles, Themes, and Pathways for Action*, which outlines the need for increased individual preparedness and community engagement. The approach defines six strategic themes:

- *Understand community complexity;*
- *Recognize community capabilities and needs;*
- *Foster relationships with community leaders;*
- *Build and maintain partnerships;*
- *Empower local action; and*
- *Leverage and strengthen social infrastructure, networks, and assets.*

The Whole Community Approach presents a foundation for engaging and empowering citizens and community groups as vital partners in enhancing disaster resilience. These strategic themes align with the set of premises, which emerged from the existing disaster literature review, and that I use to guide my research:

- Improving disaster resilience through capacity building instead of eliminating risk is central to meeting disaster management objectives;
- Social capital — individual and community networks — have proven to be a vital capacity for coping and adapting to shocks from disasters;
- Local knowledge is a key component of disaster information and knowledge management, but it is often ignored, due to functional, structural, and social barriers; and
- Leverage the existing strength and innovation to enhance collaboration across key actors in the system to achieve disaster resilience goals.

This thesis uses the Whole Community concept as practical guidance for deriving design recommendations for creating a more inclusive and effective disaster information and knowledge systems in Puerto Rico and other relevant contexts.

3. Design Recommendations

To derive the design recommendations, I first mapped the key actors and their existing capacities and needs in achieving disaster preparedness. I then evaluated a set of current community mapping solutions and how they measure up in meeting the needs of the key groups of actors and address the strategic themes of the Whole Community Approach. Based on the evaluation and informed by the Sphere and Whole Community frameworks, I summarise a set of concrete recommendations for creating integrated community mapping systems for improved disaster resilience.

3.1 Key Actors and Needs Identified

Among the wide range of stakeholders in disaster management, I focus on four key actors based on their importance in disaster information and knowledge management. I group these actors by their shared primary role and characteristics; however, I recognize the heterogeneity across individuals within the groups as well as the multiplicity of roles for some , i.e. a person with access and functional needs can also contribute to disaster response and recovery activities.

1) Actor 1: At-risk persons often have access and functional needs that may require special assistance before, during, and after a disaster, including maintaining independence, communication, transportation, and medical care. It is important to recognize everyone as dignified human beings with agency, not helpless objects. The following groups have found to be often disproportionately impacted by disasters, including post-Maria Puerto Rico:

- Frail elderly who depend on others for activities of daily living
- People who live alone or with minimum family and social connection

- People with medical conditions, such as heart disease, diabetes, kidney disease, cancer, Alzheimer's and other dementia
- People with disabilities, such as physical, sensory, and developmental
- low-income
- People who don't have means of transportation
- Others: pregnant women, immigrants, LGBTQ, non-native speakers, and those susceptible to other types of harm such as gender-based violence

2) Actor 2: Community volunteers play a key role in preparing, coping, and recovering from a disaster for themselves as well as their families, friends, and communities. The following groups were some of the major forces in the post-Maria response and recovery efforts:

- Women
- Senior citizens
- Students
- Young professionals
- Healthcare and other related professionals

3) Actor 3: CBOs have been playing vital leadership roles in disaster response and recovery efforts, especially in remote, disadvantaged areas. They come in diverse forms and below are some examples:

- Resident associations
- Professional associations
- Youth and student groups
- Political assemblies
- Faith-based groups
- Community centers

4) Actor 4: Disaster management and aid agencies play a central role in planning, coordinating, implementing, and monitoring disaster management activities. Some of these entities include:

- Government agencies
- Relevant private sectors
- Philanthropic entities
- International NGOs
- Puerto Rican NGOs

Capacity includes all the existing knowledge, strengths, attributes, and resources individuals, organizations or society have to manage and reduce disaster risks and strengthen resilience (UNDRR 2017). Capacity resides in the individual, organization, and the enabling environment, which all contribute to the concept of resilience (Wisner, Gaillard, and Kelman 2012). Capacities at the level of the enabling environment relate to laws, rules, policies, power relations, and societal norms, which all of the four key actors operate in. At the organizational level, capacities describe

internal structures, policies, and systems that determine the ability, incentives, and governance of an organization. These factors affect an organization's effectiveness in delivering on its mandates and allowing individuals to work together. At the individual level, everyone, including the vulnerable, has skills, experience, knowledge, and resources within their control that allow them to cope and adapt. However, individual capacity has to be understood within the context of organizational capacities and the enabling environment. Needs or capacity gaps are areas identified for further action in order to move from their current state to the desired, future state of improved resilience.

Based on primary and secondary research findings, I summarize the capacities and needs of the four key actors in the current system to meet disaster preparedness goals (Table 6-1).

Table 6-1. The capacities and needs of the key actors in response to a disaster. Actor 1: at-risk persons; Actor 2: community volunteers; Actor 3: CBOs; and Actor 4: disaster management and aid agencies.

	Capacities	Needs
Actor 1	● Knowledge of their access and functional needs ● Existing coping and adaptive capacities and resources	● Tailored assistance with disaster preparedness, response, and recovery such as early warning, evacuation, transportation, and accessing essential supplies and services, safe shelter, power, and medical services, etc. ● Financial and direct assistance for recovery, such as repairing damaged homes, purchasing food and other necessities ● Companionship and social connection with family members, friends, or other trusted people ● Communal space and programming for an increased sense of empowerment and belonging
Actor 2	● Existing coping and adaptive capacities and resources ● Time, resources, skills, and knowledge to help others	● Minimize exposure to harm for themselves and their connections in case of a disaster ● Coordination and direction to facilitate collective response ● Flexibility of schedule and free will ● Recognition, empowerment, opportunity for growth and learning, as well as a sense of community and belonging for continued engagement ● Economic or other forms of incentives
Actor 3	● Knowledge of community needs, capacities, and culture ● Coordination, operation, and implementation of service delivery to individuals ● Trust and social network	● Enhanced capacity, resource, and infrastructure in planning, coordinating, and implementing disaster response and recovery activities ● Improved capacity in administration, operation, fundraising, and other general managerial requirements and assistance in navigating political and other bureaucracy ● Financial and human resources for service delivery
Actor 4	● Funding, resources, and personnel ● Training and education ● High- level coordination, operation, and implementation of mandates	● Timely situational awareness of the disaster impact ● Real-time decision-making in directing response and recovery efforts and distribution of resources ● Channels and processes for coordination around logistics, supplies, and resources across actors ● Delivering services to the right places at the right time

3.2 Current Community Mapping Efforts

To help direct and coordinate disaster management efforts, information on vulnerabilities and resources of communities is crucial. However, in many parts of the world, information on vulnerable populations and places are often missing. Community mapping has become a crucial path to acquiring such information and present an entry point for connecting the dots among key actors in the system. However, formal disaster information and management channels have not widely leveraged community information and knowledge, while recognizing that existing data would need to be more specific to aid agencies in adjusting its response operations and supporting actionable operational decisions (FEMA 2018). I present three groups of solutions that have been developed to map community vulnerabilities and resources that are led by digital volunteers, external NGOs, and local CBOs.

3.2.1 Digital Volunteers

Advances in information and communication technology have enabled mass information and knowledge dissemination and production. Platforms such as Humanitarian OpenStreetMaps and CrowdSource Rescue tap into the power of volunteers from outside of the affected communities to gather information to assess the disaster situation. These are usually short-term initiatives activated after disasters take place. Such efforts have helped to map missing information using remote sensing and geospatial tools as well as social media. These platforms can quickly amass a large number of volunteers and perform large amounts of work fast, providing disaster managers quick assessments of the situation to help decision-making under time pressure. These platforms are relatively accessible to official disaster managers given their digital and online functions.

However, such external efforts do not yet successfully incorporate the rich local, tacit knowledge that is invaluable in directing essential services to vulnerable populations. To participate in such platforms, people will need access to a network, computers, energy sources, and knowledge and experience with using the tools. In post-disaster areas, access to these prerequisites is often a challenge, limiting local participation and reporting on situational information. There are also questions about data quality without adequate ground truthing. For those relying on geospatial technology, these efforts often take place after disasters happen while using potentially outdated remote sensing images, which may lead to inaccurate or unusable information for humanitarian efforts. For those that rely on social media, lack of participant interest may mean that there will be pockets of impacted areas that go unnoticed. Lastly, because these platforms generally focus on assisting disaster response efforts, the information gathered may not be available or suitable community efforts to build long-term resilience.

3.2.2 External NGOs

Many aid organizations such as Mercy Corps and ConnectRelief have led initiatives to map needs and resources in communities. Such efforts often serve as the basis of community planning efforts and to help direct aid resources to places of the greatest needs. However, these initiatives that rely on leadership and volunteers from outside of the communities are often difficult to scale and

sustain, given logistical and resource challenges. It also takes considerable time and effort for external entities to build and navigate trust issues when it comes to sensitive information about communities and individuals. Additionally, given the resource-intensive nature of community mapping, NGOs often lack the staffing capacity to continuously monitor changes to ensure that information is complete and up-to-date. However, these initiatives have shown to be beneficial to both the communities and external NGOs as the deliberate efforts to develop relationships serve as a bridge for building longer-term partnerships that allow for trust building and collaboration. With additional funding, resources, and training, these initiatives can also help local communities build new skills and capacities.

3.2.3 Local CBOs and Volunteers

After Hurricane Maria, with the deep connection and understanding of the needs and dynamics of their communities, many CBOs are taking upon themselves to map community vulnerabilities and resources. Even with low cost and technology, local CBOs and their volunteers have created sophisticated information and knowledge management systems that capture the complexities of the community they serve in and in formats that are most comfortable for those who deploy the system. However, currently, these initiatives rely on a few community leaders or volunteers to manually source, document, and manage information (demographic information, medical conditions, etc.) on paper or printed maps. Not only do they share the resource and staff limitations as aid organizations, but CBOs also often lack the technical infrastructure to manage and share with relevant stakeholders. In addition to the above-mentioned challenges, local information about communities is often not immediately usable or actionable for aid agencies for disaster response or recovery efforts, as information from external entities or knowledge groups often requires additional processing and transformation to meet the institutional and/or regulatory standards, internal workflow, and staff capacity to be effectively integrated.

As FEMA's Whole Community Approach provides guiding principles for engaging and empowering citizens and community groups, I evaluated how these solutions apply one or more of the strategic themes (Table 6-2). Currently, no one solution meets all the strategic themes but each brings a set of strengths that can be leveraged and integrated to improve the system. Table 6-3 summarises their strengths and gaps in meeting the needs of the key stakeholders

Table 6-2. Evaluation of how current community mapping solutions using strategic themes of the Whole Community Approach. ST1: Understand community complexity; ST2: Recognize community capabilities and needs; ST3: Foster relationships with community leaders; ST4: Build and maintain partnerships; ST5: Empower local action; and ST6: Leverage and strengthen social infrastructure, networks, and assets. The initiatives are color-coded as green as apply and yellow as not apply.

Solution Lead	ST1	ST2	ST3	ST4	ST5	ST6
Digital Volunteers						
External NGOs						
Local CBOs and Volunteers						

Table 6-3. Strengths and gaps of the current community mapping solutions.

Solution Lead	Strengths	Gaps
Digital Volunteers	● Amass a large number of volunteers quickly ● Provide quick information to assist time-critical decision-making ● Use a variety of information sources, including satellite images and social media ● Circumvent infrastructure failures and other challenges that prevent information gathering in the affected regions ● Platform for easy sharing with disaster management and aid agencies	● Do not incorporate local knowledge ● High barriers for local participation after disasters happen due to limitations in access to energy, network, as as well as skills and experience ● Cannot easily ground truth or verify data quality ● Lack of participation may lead to negligence ● Source data (e.g. satellite images) may be outdated ● Initiatives are usually short-term and not designed for building long-term resilience
External NGOs	● Opportunity for building long-term partnerships between external NGOs and communities ● Additional funding, resources, and personnel from outside of communities ● Opportunity to cultivate local leader and build new skills and capacity	● Initial challenges around trust-building with communities to obtain information and to understand complexities and dynamics necessary for disaster response and recovery ● Limited resource and staffing for long-term maintenance
Local CBOs and Volunteers	● Deep connection and understanding of community needs, capacity, and culture ● Appropriate for local deployment	● Limited resources and human capital for long-term maintenance ● Lack of technical infrastructure for effective management and sharing of information ● High barriers for disaster management and aid agencies to adopt without prior agreement on data processes and standard, given current structural barriers in information sharing and coordination

3.3 Design Recommendations

Guided by the Whole Community Approach and the set of premises from existing disaster research, I propose a set of design recommendations for developing integrated community mapping systems that draw on strengths from existing efforts that build on capacities and meet the identified needs of key actors.

In general, CBOs can function as the central player that connects the other actors in the system. CBOs provide services, supplies, and other support to community members. They also mobilize and coordinate action among community volunteers to augment their human capital to deliver services and mission, especially to those with access and functional needs. CBOs could serve as an important channel for disaster management and aid agencies for coordinating and implementing their programs. However, CBOs often rely on funding, resources, and capacity building produced by these agencies to fulfill their role and sustain their mission.

In summary, the integrated community mapping systems seek to solve the following challenges:

- With limited experience and operational constraints to respond to disasters, CBOs find it difficult to pivot and sustain new missions in disaster response and recovery;
- With different organizational structures and information management procedures, coordination across disaster management stakeholders has been challenging; and
- With inadequate information about the community's vulnerabilities and resources, disaster response work becomes hectic and ineffective.

3.3.1 Mobilize Local Community Volunteers

Develop training materials and management systems in collaboration with CBOs for effectively recruiting and supporting local community volunteers to meet the demand for disaster management and build long-term resilience. Community volunteers are the most powerful force to unite to respond to humanitarian crises and to build long-term disaster resilience. It is important to empower CBOs with training and technology — from communication strategy to volunteer management — to mobilize and support local residents. To build sustaining relationships, coordination will be important to create meaningful experiences for volunteers and to ensure value-added to disaster management efforts. For the most vulnerable populations such as isolated seniors who often have limited access and experience with technology, local community volunteers, who are likely their trusted neighbors and friends, bridge the digital gap and provide much-needed companionship. Together with volunteers, CBOs will be able to expand their capacity in disaster management efforts to meet the surging demand for human resources during and after crises while improving social networks that serve as one of the most important factors in community resilience.

3.3.2 Build and Maintain New Partnerships

Bring CBOs and disaster management and aid agencies together to form and maintain partnerships that go beyond the immediate needs around crisis management. To allow agencies to effectively coordinate with CBOs and citizens, new governance structures, protocols, and communication channels need to be established and tested before disasters hit. CBOs often have limited capacity and information to identify the right entities to ask for help, while aid agencies and philanthropic entities face challenges in finding the right places to provide resources and supplies. These partnerships will allow trust-building to help streamline the distribution of resources, services, and information, facilitating time-critical decision-making required for disaster management. Finally, the partnership will allow CBOs and agencies to co-create information and knowledge management protocols for effective and inclusive acquisition, management, and sharing of information.

3.3.3 Use Technology as a Catalyst

Co-design easy-to-use mobile and web-based platforms with CBOs and aid agencies to crowdsource, manage, and communicate community needs with a focus on vulnerable individuals. To help direct and coordinate disaster management efforts, information on vulnerabilities and resources of communities is crucial. However, current information on vulnerable populations and places are

often missing, unusable, or illegible. Based on field research with community health workers, the mobile and web-based platform has the potential to allow volunteers and CBOs to collect key information for disaster response and recovery efforts. However, it is crucial to understand the infrastructure constraints of the community and work with the users to develop instruments that meet their experience and comfort levels with technology.

To help improve disaster information and knowledge management, it is crucial to capture human-level data, including medical needs, transportation, and other demographic information, which will require on-the-ground surveys that take place before disasters hit. Other types of information such as those crowdsourced from digital volunteers as well as satellite images and government data are also critical for disaster management efforts, especially for assessing post-disaster damages at scale. Effective integration, analysis, and communication of these different data sources to key actors will be vital.

To illustrate how the integrated community mapping information systems would allow for more effective disaster management and build resilience, figure 6-1 maps demonstrate how resources, services, and information would flow in the system.

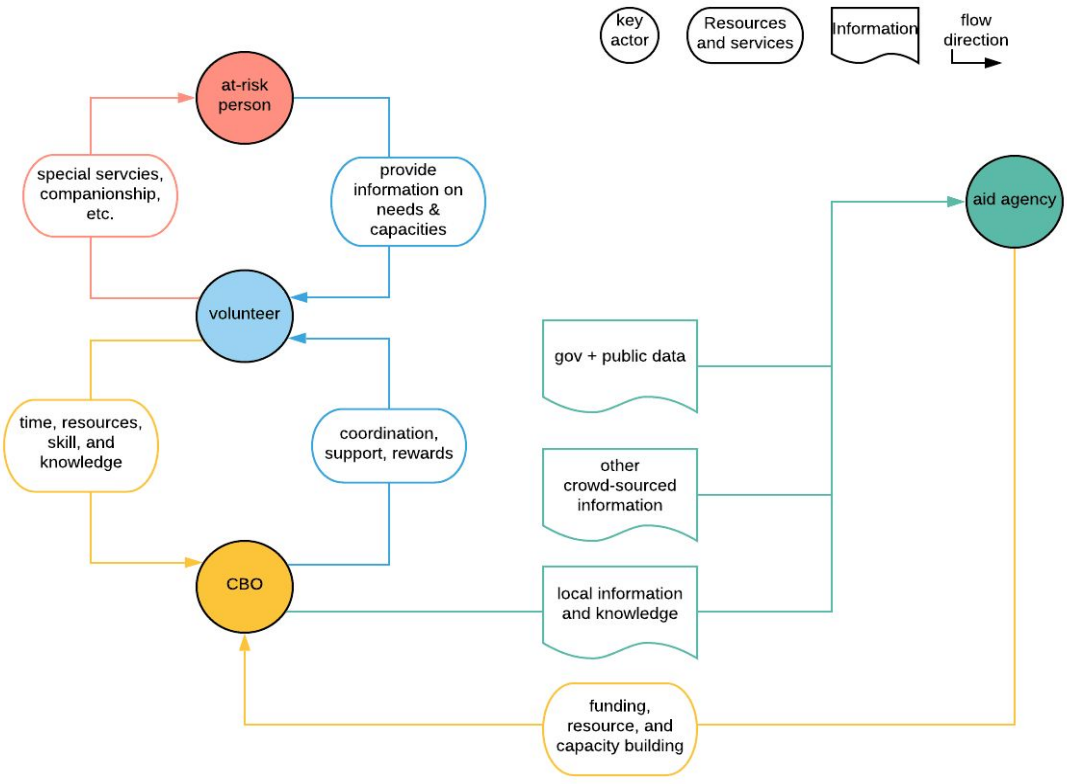


Figure 6-1. Resource, service, and information flow through an integrated community mapping system.

CHAPTER 7: SUMMARY

1. Discussion

This thesis first examined the impacts of Hurricane Maria and the factors that contributed to the disparities across the island. Accounts from the field highlighted emergent actions from citizens and community groups in response to the catastrophe when government agencies failed to provide adequate support, which was further illustrated through the case study of COSSAO's Community Health Promoter Project. The current gap between the official agencies and the emergent citizens and community groups in the disaster management system calls for action.

As places like Puerto Rico face growing challenges from natural disasters, it is clear that no government agency or jurisdiction has enough resources and capacities to prepare and respond to emergencies alone. Engaging and empowering individuals and community groups who will provide the much-needed capacity is vital in responding to more frequent and severe disasters. However, individuals and groups working outside of the official disaster management system have been largely undervalued through the current formal institutional structures and arrangements that employ bureaucratic, command-and-control approaches.

The assumptions that underpin these command-and-control approaches create barriers for engaging emergent citizens and community groups, which include: 1) information outside of official channel is lacking or inaccurate; 2) standard operations will always function in disasters; departures from standard operation producers are detrimental; 3) citizens are inept, passive or non-participants; and 4) ad hoc emergence is counterproductive (Drabek and McEntire 2003). Disaster research and accounts from the field challenge many of the assumptions and show that citizens and community groups demonstrate adaptability, innovativeness, and responsiveness in the face of crisis, where strong social networks and structures are the driving forces for recovery after disasters.

These findings call for a different approach to disaster management that values the emergence of citizens and community groups and the time, skill, knowledge, and resources they offer. Effective disaster management requires both "agility" (creativity, improvisation, adaptability) to ensure coordination and communication, as well as discipline (structure, doctrine, process) for mobilizing and managing large organizations (Harrald 2006). However, the current disaster management relies heavily on the discipline of the established entities, with little agility to allow the participation of emergent individuals and community groups.

For disaster management agencies to move towards a more "agile" system, Stallings and Quarantelli (1985) offer five principles that shed light on how to work with individuals and community groups in the face of disasters: 1) emergence is inevitable in the face of disasters as citizens will identify needs that are not being met, which may be real or perceived; 2) the "looseness" of the informal structure of citizens and community group is a real strength as they are not constrained by

established structures when new tasks need to be performed; 3) although citizens and community groups may not deploy the ideal approach, it should be acknowledged that alternative approaches are available; 4) citizens and community groups may rise to the unmet needs, but they are not always in opposition to public agencies; and 5) emergent citizens and community groups cannot be eliminated through prior planning, therefore it's important for emergency managers to consider how to facilitate and collaborate to add value to the overall disaster management.

As recognized in FEMA's Whole Community Approach, to truly engage and empower citizens and community groups will require the disaster management community to transform their thinking, planning, and practice to find the balance between "discipline" and "agility." Inspired by the strength and resilience embodied by the Puerto Rican people, this study proposed design recommendations to invite scholars and practitioners to explore community mapping as a path to help break through the gridlock between citizens, CBOs, and agencies. A collaborative platform, it presents opportunities to facilitate new conversations to move the disaster management community beyond the old assumptions towards a more collaborative, resilient future.

2. Limitations

This study sought to explore the complex social system of disaster management in Puerto Rico and to identify potential points of intervention for improvement. Limitations of the study are a result of both the nature of the subject and the research process that I was able to deploy.

As a major part of the study relied on interviews and participatory observation, intersubjectivity and other biases were inevitable. The study spanned across over a year through an exploratory and iterative process, which could lead to inconsistencies in fieldwork and conflicting data across temporal scales. Throughout the span of my research, several major natural disasters (Hurricane Dorian and earthquakes) took place in Puerto Rico, adding new layers of unexpected complexities in regards to how individuals and communities relate to disasters on the Island. At the time of my fieldwork, more than a year and a half had passed since the landing of Hurricane Maria, therefore people's recollection of and relationship with the event had also evolved. To mitigate this, interviews were corroborated with each other and supplemented with secondary research such as official reports and archival media resources documenting the disaster events. To clarify details and to build on new discoveries and questions, follow-up interviews were conducted when possible and necessary. Due to the limitation of time, geographic differences, and access to some stakeholders, there were many more interviews with NGOs, CBOs, and academic/research institutions than with government representatives, leading to potential biases in my understanding of the system.

As the design recommendation relied on my interpretation of the needs and capacities of the different actors as well as the evaluation of the current initiatives in relation to established principles, the process was partially subjective. While I strived to provide context to explain what factors influenced the complex events and processes, the external validity of the study may be limited and cannot be readily generalized for other locations beyond Puerto Rico. However, this

study was not meant to be all-encompassing given the extremely complex and context-dependent nature of disaster management.

3. Future Work

This thesis presents accounts from the field across several representative communities in Puerto Rico and proposes preliminary design recommendations on integrated community mapping for scholars and practitioners to explore as a pathway for building resilience. Further studies will be needed to validate these recommendations and test design options for key touchpoints on the ground. Studies with greater coverage of communities in Puerto Rico and other relevant contexts will be needed to explore the external validity of the findings. Other types of communities for engagements may include those in under-resourced urban areas, remote rural communities in the mainland U.S., disadvantaged communities on the coasts, and communities in other small island nations. The study was developed in the context of hurricanes, this work can also be expanded to building resilience for other hazards — public health crisis, earthquake, flood, wildfire — many of which present their own challenges and may require different frameworks of analysis. Lastly, disaster management, as I learned through my exploratory, generative research process, links with a myriad of fields of study. Many more intersections could be explored in-depth for new inspirations and discoveries to help expand on the preliminary design considerations, including psychology and behavior, network theory, information technology, and communication.

REFERENCES

Acevedo, Nicole. 2018. "'The Push We Needed': Puerto Rico's Local Farmers Step up Efforts after Hurricane Maria." 2018. https://www.nbcnews.com/storyline/puerto-rico-crisis/push-we-needed-puerto-rico-s-local-farmers-step-efforts-n875491.

———. 2019. "Amid Government Mess, Hurricane Maria Survivors Lack Access to Philanthropic Aid." NBC News. 2019. https://www.nbcnews.com/news/latino/amid-government-mess-hurricane-maria-survivors-lack-access-philanthropic-aid-n1056221.

Adger, W. Neil. 2003. "Social Capital, Collective Action, and Adaptation to Climate Change." *Economic Geography* 79 (4): 387–404. https://doi.org/10.1111/j.1944-8287.2003.tb00220.x.

———. 2006. "Vulnerability." *Global Environmental Change* 16 (3): 268–81. https://doi.org/10.1016/j.gloenvcha.2006.02.006.

Agosto-Maldonado, Lillian E. 2018. "Puerto Rico: Nonprofits Recalibrate after Hurricane Maria." Spotlight on Poverty and Opportunity. 2018. https://spotlightonpoverty.org/spotlight-exclusives/puerto-rico-nonprofits-recalibrate-after-hurricane-maria/.

Aldrich, Daniel P. 2012. *Building Resilience: Social Capital in Post-Disaster Recovery*. University of Chicago Press. https://press.uchicago.edu/ucp/books/book/chicago/B/bo13601684.html.

———. 2019. *Black Wave: How Networks and Governance Shaped Japan's 3/11 Disasters*. University of Chicago Press. https://www.press.uchicago.edu/ucp/books/book/chicago/B/bo40026774.html.

Aldrich, Daniel P., and Emi Kyota. 2017. "Creating Community Resilience Through Elder-Led Physical and Social Infrastructure." *Disaster Medicine and Public Health Preparedness* 11 (1): 120–26. https://doi.org/10.1017/dmp.2016.206.

Aldrich, Daniel P., and Michelle A. Meyer. 2015. "Social Capital and Community Resilience." *American Behavioral Scientist* 59 (2): 254–69. https://doi.org/10.1177/0002764214550299.

Alicea, Keila López. 2018. "Las organizaciones sin fines de lucro ayudaron a un millón de afectados." El Nuevo Dia. March 25, 2018. https://www.elnuevodia.com/noticias/locales/nota/lasorganizacionessinfinesdelucroayudaronaunmillondeafectados-2409171/.

Allen, Greg, and Marisa Peñaloza. 2019. "'I Don't Feel Safe': Puerto Rico Preps For Next Storm Without Enough Government Help." NPR.Org. 2019. https://www.npr.org/2019/07/03/737001701/i-don-t-feel-safe-puerto-rico-preps-for-another-maria-without-enough-government.

Almukhtar, Sarah, Matthew Bloch, Ford Fessenden, and Jugal K. Patel. 2017. "Maps: Hurricane Maria's Path Across Puerto Rico." *The New York Times*, September 18, 2017, sec. World. https://www.nytimes.com/interactive/2017/09/18/world/americas/hurricane-maria-tracking-map.html.

Andrade, Elizabeth, Nicole Barrett, Uriyoan Colón-Ramos, Mark Edberg, Alejandra Garcia-Meza, Ann Goldman-Hawes, Lynn Goldman, et al. 2018. "Ascertainment of the Estimated Excess Mortality from Hurricane María in Puerto Rico." The George Washington University Milken

Institute School of Public Health.
Berke, Philip, John Thomas Cooper Jr, David Slavesen, and Danielle Spurlock. 2010. "Disaster Plans: Challenges and Choices to Build Resiliency of Vulnerable Populations." *International Journal of Mass Emergencies and Disasters* 28 (2): 368–94.
Berkes, Fikret. 2007. "Understanding Uncertainty and Reducing Vulnerability: Lessons from Resilience Thinking." *Natural Hazards* 41 (2): 283–95. https://doi.org/10.1007/s11069-006-9036-7.
Bessette-Kirton, Erin K., Corina Cerovski-Darriau, William H. Schulz, Jeffrey A. Coe, Jason W. Kean, Matthew A. Thomas, Jonathan W. Godt, and K. Stephen Hughes. 2019. "Landslides Triggered by Hurricane Maria: Assessment of an Extreme Event in Puerto Rico." *GSA Today* 29 (6): 4–10. https://doi.org/10.1130/GSATG383A.1.
Bharosa, Nitesh, JinKyu Lee, and Marijn Janssen. 2010. "Challenges and Obstacles in Sharing and Coordinating Information during Multi-Agency Disaster Response: Propositions from Field Exercises." *Information Systems Frontiers* 12 (1): 49–65. https://doi.org/10.1007/s10796-009-9174-z.
Bharosa, Nitesh, JinKyu Lee, Marijn Janssen, and H. Raghav Rao. 2012. "An Activity Theory Analysis of Boundary Objects in Cross-Border Information Systems Development for Disaster Management." *Security Informatics* 1 (1): 15. https://doi.org/10.1186/2190-8532-1-15.
Birkmann, Joern. 2006. "Measuring Vulnerability to Promote Disaster-Resilient Societies: Conceptual Frameworks and Definitions." *Institute for Environment and Human Security Journal* 5 (January): 7–54.
———. 2007. "Risk and Vulnerability Indicators at Different Scales: Applicability, Usefulness and Policy Implications." *Environmental Hazards* 7: 20–31.
Brown, Nick. 2018. "Special Report: In Puerto Rico, a Housing Crisis U.S. Storm Aid Won't Solve." *Reuters*, February 6, 2018. https://www.reuters.com/article/us-usa-puertorico-housing-specialreport-idUSKBN1FQ211.
Burnette, Denise. 2019. "Feasibility of an Evidence-Based Mental Health Intervention with Older Adults in Post-Hurricane Maria Puerto Rico." *Innovation in Aging* 3 (Suppl 1): S542. https://doi.org/10.1093/geroni/igz038.1993.
Carlile, Paul. 2002. "A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development. Sloan." *ORGANIZATION SCIENCE* 13 (August): 442-455 %U http://orgsci.journal.informs.org/cgi/content/abstract/13/4/442. https://doi.org/10.1287/orsc.13.4.442.2953.
Chinoy, Sahil. 2018. "The Places in the U.S. Where Disaster Strikes Again and Again," 2018. https://www.nytimes.com/interactive/2018/05/24/us/disasters-hurricanes-wildfires-storms.html.
Clement, Scott, Katie Zezima, and Emily Guskin. 2018. "Hurricane Maria: Puerto Ricans Say All Levels of Government Failed Them after Devastating Storm." Washington Post. 2018. https://www.washingtonpost.com/news/national/wp/2018/09/12/feature/residents-see-a-failure-at-all-levels-of-government/.
Coleman-Jensen, Alisha, Matthew P. Rabbitt, Christian A. Gregory, and Anita Singh. 2018. "Household Food Security in the United States in 2018." http://www.ers.usda.gov/publications/pub-details/?pubid=94848.
COR3, and Government of Puerto Rico. 2018. "Transformation and Innovation in the Wake of Devastation: An Economic and Disaster Recovery Plan for Puerto Rico." Central Office for Recovery, Reconstruction and Resilience.

Corburn, Jason. 2003. “Bringing Local Knowledge into Environmental Decision Making Improving Urban Planning for Communities at Risk.” *Journal of Planning Education and Research* 22: 420–33.
COSSAO. 2019. “Corporación de Servicios de Salud Primaria Y Desarrollo Socioeconómico El OTOAO Information Booklet.”
Cruz-Cano, Raul, and Erin L. Mead. 2019. “Causes of Excess Deaths in Puerto Rico After Hurricane Maria: A Time-Series Estimation.” *American Journal of Public Health* 109 (7): 1050–52. https://doi.org/10.2105/AJPH.2019.305015.
Cutter, Susan L., Kevin D. Ash, and Christopher T. Emrich. 2014. “The Geographies of Community Disaster Resilience.” *Global Environmental Change* 29 (November): 65–77. https://doi.org/10.1016/j.gloenvcha.2014.08.005.
Cutter, Susan L., Bryan J. Boruff, and W. Lynn Shirley. 2003. “Social Vulnerability to Environmental Hazards.” *Social Science Quarterly* 84 (2): 242–61. https://doi.org/10.1111/1540-6237.8402002.
Cutter, Susan L., Christopher G. Burton, and Christopher T. Emrich. 2010. “Disaster Resilience Indicators for Benchmarking Baseline Conditions.” *Journal of Homeland Security and Emergency Management* 7 (1). https://doi.org/10.2202/1547-7355.1732.
Cutter, Susan L., and Christina Finch. 2008. “Temporal and Spatial Changes in Social Vulnerability to Natural Hazards.” *Proceedings of the National Academy of Sciences* 105 (7): 2301–6. https://doi.org/10.1073/pnas.0710375105.
DasGupta, Rajarshi, and Rajib Shaw. 2017. “Disaster Risk Reduction: A Critical Perspective.” In *The Routledge Handbook of Disaster Risk Reduction Including Climate Change Adaptation*, edited by Ilan Kelman, Jessica Mercer, J. C. Gaillard, Jessica Mercer, and J. C. Gaillard. Routledge. https://doi.org/10.4324/9781315684260.
Daub, Traub. 2017. “Hurricane Relief Isn’t Reaching Remote Areas of Puerto Rico.” PBS NewsHour. September 27, 2017. https://www.pbs.org/newshour/show/hurricane-relief-isnt-reaching-remote-areas-puerto-rico.
Dekens, Julie. 2007. “Local Knowledge for Disaster Preparedness: A Literature Review.” Kathmandu, Nepal: International Centre for Integrated Mountain Development.
Dickerson, Caitlin. 2017. “Stranded by Maria, Puerto Ricans Get Creative to Survive.” *The New York Times*, October 16, 2017, sec. U.S. https://www.nytimes.com/2017/10/16/us/hurricane-maria-puerto-rico-stranded.html.
DiJulio, Bianca, and Cailey Muñana. 2018. “Views and Experiences of Puerto Ricans One Year After Hurricane Maria - Section 2: Moving Forward with Recovery and Continued Need.” *The Henry J. Kaiser Family Foundation* (blog). September 12, 2018. https://www.kff.org/report-section/views-and-experiences-of-puerto-ricans-one-year-after-hurricane-maria-section-2-moving-forward-with-recovery-and-continued-need/.
Downer, Brian, Michael Crowe, and Kyriakos S. Markides. 2019. “Population Aging and Health in Puerto Rico.” In *Contextualizing Health and Aging in the Americas: Effects of Space, Time and Place*, edited by William A. Vega, Jacqueline L. Angel, Luis Miguel F. Gutiérrez Robledo, and Kyriakos S. Markides, 7–17. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-00584-9_1.
Drabek, Thomas E., and David A. McEntire. 2003. “Emergent Phenomena and the Sociology of Disaster: Lessons, Trends and Opportunities from the Research Literature.” *Disaster Prevention and Management: An International Journal* 12 (2): 97–112. https://doi.org/10.1108/09653560310474214.

Dynes, Russell R. 1994. “Community Emergency Planning: False Assumptions and Inappropriate Analogies.” http://udspace.udel.edu/handle/19716/1626.
Engeström, Y. 2000. “Activity Theory as a Framework for Analyzing and Redesigning Work.” *Ergonomics* 43 (7): 960–74. https://doi.org/10.1080/001401300409143.
Family Caregiver Alliance. 2006. “Caregiver Health.” 2006. https://www.caregiver.org/caregiver-health.
Farinas, Yaremi. 2018. “Rural Mountain Town in Puerto Rico among Hardest Hit by Hurricane Maria | WPEC.” February 5, 2018. https://cbs12.com/news/impact-puerto-rico/rural-mountain-town-in-puerto-rico-among-hardest-hit-by-hurricane-maria.
FEMA. 2011. “A Whole Community Approach to Emergency Management: Principles, Themes, and Pathways for Action.”
———. 2018. “2017 Hurricane Season FEMA After-Action Report.” Federal Emergency Management Agency. https://www.hsdl.org/?abstract&did=.
Fericelli, Paul-Jesús. 2013. “Family Assistance for Older Adults in Puerto Rico.” *Advances in Social Work* 14 (1): 276–88. https://doi.org/10.18060/3809.
Ferré, Isabella M., Stephanie Negrón, James M. Shultz, Seth J. Schwartz, James P. Kossin, and Hilda Pantin. 2019. “Hurricane Maria’s Impact on Punta Santiago, Puerto Rico: Community Needs and Mental Health Assessment Six Months Postimpact.” *Disaster Medicine and Public Health Preparedness* 13 (1): 18–23. https://doi.org/10.1017/dmp.2018.103.
Ferré-Sadurní, Luis. 2017. “In a Puerto Rican Town, ‘Water Came Out of Nowhere.’” *The New York Times*, 2017. https://www.nytimes.com/2017/09/22/us/puerto-rico-toa-baja-hurricane-.html.
Fink, Sheri. 2018. “Puerto Rico: How Do We Know 3,000 People Died as a Result of Hurricane Maria?” *The New York Times*, June 2, 2018, sec. U.S. https://www.nytimes.com/2018/06/02/us/puerto-rico-death-tolls.html.
Fothergill, Alice, and Lori A. Peek. 2004. “Poverty and Disasters in the United States: A Review of Recent Sociological Findings.” *Natural Hazards* 32 (1): 89–110. https://doi.org/10.1023/B:NHAZ.0000026792.76181.d9.
Gallopín, Gilberto C. 2006. “Linkages between Vulnerability, Resilience, and Adaptive Capacity.” *Global Environmental Change*, Resilience, Vulnerability, and Adaptation: A Cross-Cutting Theme of the International Human Dimensions Programme on Global Environmental Change, 16 (3): 293–303. https://doi.org/10.1016/j.gloenvcha.2006.02.004.
Garcia, Ivis. 2020. “The Lack of Proof of Ownership in Puerto Rico Is Crippling Repairs in the Aftermath of Hurricane Maria.” 2020. https://www.americanbar.org/groups/crsj/publications/human_rights_magazine_home/vol--44--no-2--housing/the-lack-of-proof-of-ownership-in-puerto-rico-is-crippling-repai/.
Gay, Hiram A., Roberto Santiago, Betty Gil, Carlos Remedios, Pedro J. Montes, Javier López-Araujo, Carlos M. Chévere, et al. 2019. “Lessons Learned From Hurricane Maria in Puerto Rico: Practical Measures to Mitigate the Impact of a Catastrophic Natural Disaster on Radiation Oncology Patients.” *Practical Radiation Oncology* 9 (5): 305–21. https://doi.org/10.1016/j.prro.2019.03.007.
Gill, Duane, and Liesel Ritchie. 2017. “Contributions of Technological and Natech Disaster Research to the Social Science Disaster Paradigm.” In *Handbook of Disaster Research*, 39–60. https://doi.org/10.1007/978-3-319-63254-4_3.
Gillespie, Patrick, Rafael Romo, and Maria Santana. 2017. “Puerto Rico Aid Is Trapped in Thousands of Shipping Containers.” 2017.

https://www.cnn.com/2017/09/27/us/puerto-rico-aid-problem/index.html.
Greenbaum, Zara. 2019. “Puerto Rico, Two Years after Maria.” Https://Www.Apa.Org. 2019. https://www.apa.org/monitor/2019/09/puerto-rico.
Harmsen, Eric W., Norman L. Miller, Nicole J. Schlegel, and J. E. Gonzalez. 2009. “Seasonal Climate Change Impacts on Evapotranspiration, Precipitation Deficit and Crop Yield in Puerto Rico.” *Agricultural Water Management* 96 (7): 1085–95. https://doi.org/10.1016/j.agwat.2009.02.006.
Harrald, John R. 2006. “Agility and Discipline: Critical Success Factors for Disaster Response.” *The ANNALS of the American Academy of Political and Social Science* 604: 256–72.
Hennessy-Fiske, Molly. 2017. “She Was Covered in Insects and Unable to Walk: Doctors in Puerto Rico Only Now Discovering the Problems in Remote Towns.” Los Angeles Times. October 6, 2017. https://www.latimes.com/nation/la-na-puerto-rico-remote-mountain-town-20171005-story.html.
Heredia-Morales, Manuel, Ralph Rivera-Gutiérrez, Heriberto Marín-Centeno, Aurinés Torres-Sánchez, and Pablo Mendez-Lázaro. 2019. “Developing and Implementing a Community Based Primary Health Care Model with Community Health Promoters for the Otoao Communities in Utuado, Puerto Rico.”
Hernández, Arelis R., closeArelis R. HernándezReporter covering the U. S. Southern border, Immigration, Texas, and beyondEmailEmailBioBioFollowFollowJeff Stein closeJeff SteinEmailEmailBioBioFollowFollow. 2019. “Puerto Rico Is in Chaos, and Some Worry Continued Instability Is a Major Threat.” Washington Post. 2019. https://www.washingtonpost.com/national/puerto-rico-is-in-chaos-and-some-worry-continued-instability-is-a-major-threat/2019/07/18/3dbfb416-a8b8-11e9-9214-246e594de5d5_story.html.
Hernández, Arelis R., and family. 2018. “A Year after Maria, Puerto Rico’s Economy Remains Feeble.” Washington Post. 2018. https://www.washingtonpost.com/national/a-year-after-maria-puerto-ricos-economy-remains-feeble/2018/09/12/a947ce78-b136-11e8-aed9-001309990777_story.html.
Hernández Ayala, José J., David Keellings, Peter R. Waylen, and Corene J. Matyas. 2017. “Extreme Floods and Their Relationship with Tropical Cyclones in Puerto Rico.” *Hydrological Sciences Journal* 62 (13).
Hinojosa, Jennifer, and Edwin Meléndez. 2018a. “Puerto Rican Exodus: One Year Since Hurricane Maria | Centro de Estudios Puertorriqueños.” 2018. https://centropr.hunter.cuny.edu/research/data-center/research-briefs/puerto-rican-exodus-one-year-hurricane-maria.
———. 2018b. “The Housing Crisis in Puerto Rico and the Impact of Hurricane Maria | Centro de Estudios Puertorriqueños.” 2018. https://centropr.hunter.cuny.edu/research/data-center/research-briefs/housing-crisis-puerto-rico-and-impact-hurricane-maria.
Holladay, Patrick J., Pablo Mendez-Lazaro, Heriberto Marin Centeno, Ralph Rivera-Gutierrez, Keenan Adams, and Katja Brundiers. 2019. “Utuado, Puerto Rico and Community Resilience Post-Hurricane Maria: The Case of Tetuan Reborn.” *Recreation, Parks, and Tourism in Public Health* 3: 5–16. https://doi.org/10.2979/rptph.3.1.02.
Howard, Bailey. 2019. “Mapa de Red de Actores Del Corporación de Servicios de Salud Primaria y Desarrollo Socioeconómico El OTOAO (COSSAO).”
Hurlbert, Jeanne S., Valerie A. Haines, and John J. Beggs. 2000. “Core Networks and Tie Activation:

What Kinds of Routine Networks Allocate Resources in Nonroutine Situations?" *American Sociological Review* 65 (4): 598–618. https://doi.org/10.2307/2657385.
Irfan, Umair. 2017. "Puerto Rico Is Slipping into an Environmental Crisis." Vox. October 26, 2017. https://www.vox.com/energy-and-environment/2017/10/26/16523868/toxic-waste-hurricane-maria-epa-superfund-puerto-rico.
Jiang, Yiping, Yufei Yuan, Kai Huang, and Lindu Zhao. 2012. "Logistics for Large-Scale Disaster Response: Achievements and Challenges." In *2012 45th Hawaii International Conference on System Sciences*, 1277–85. https://doi.org/10.1109/HICSS.2012.418.
Jones, Lucy. 2018. *The Big Ones: How Natural Disasters Have Shaped Us and What We Can Do about Them*. Doubleday Books. https://www.goodreads.com/work/best_book/57394140-the-big-ones-how-natural-disasters-have-shaped-us-and-what-we-can-do-a.
Junta de Planificación Oficina del Gobernador. 2017. "Índice de Desarrollo Socioeconómico Municipal." Gobierno de Puerto Rico. https://estadisticas.pr/index.php/en/1-estadisticas-socialesdemograficas- y-conexas.
Keellings, David, and José J. Hernández Ayala. 2019. "Extreme Rainfall Associated With Hurricane Maria Over Puerto Rico and Its Connections to Climate Variability and Change." *Geophysical Research Letters* 46 (5): 2964–73. https://doi.org/10.1029/2019GL082077.
Kendra, James M., Lauren A. Clay, and Kimberly B. Gill. 2018. "Resilience and Disasters." In *Handbook of Disaster Research*, edited by Havidán Rodríguez, William Donner, and Joseph Trainor. https://link.springer.com/book/10.1007%2F978-3-319-63254-4.
Kishore, Nishant, Domingo Marqués, Ayesha Mahmud, Mathew V. Kiang, Irmary Rodriguez, Arlan Fuller, Peggy Ebner, et al. 2018. "Mortality in Puerto Rico after Hurricane Maria." *New England Journal of Medicine* 379 (2): 162–70. https://doi.org/10.1056/NEJMsa1803972.
Klein, Naomi. 2018. *The Battle For Paradise: Puerto Rico Takes on the Disaster Capitalists*. Chicago, Illinois: Haymarket Books.
LaRocco, Dawn Giel, Contessa Brewer,Lori Ann. 2017. "Puerto Rico, Short on Fuel, Cannot Deliver Food and Medicine to the Victims of Hurricane Maria." CNBC. September 28, 2017. https://www.cnbc.com/2017/09/28/puerto-ricos-fuel-supply-breaks-down-in-the-wake-of-marias-devastation.html.
Liboiron, Max. 2015. "Disaster Data, Data Activism: Grassroots Responses to Representations of Superstorm Sandy." In *Extreme Weather and Global Media.*, edited by Diane Negra and Julia Leyda. Routledge.
Lybarger, Jeremy. 2018. "Mental Health in Puerto Rico." *Https://Www.Apa.Org* 49 (5): 20.
Mares, Teresa M. 2019. "CULTIVATING COMIDA: What Maria Exposed to Us." *Journal of Agriculture, Food Systems, and Community Development* 9 (1): 7–11. https://doi.org/10.5304/jafscd.2019.091.033.
Mayunga, Joseph. 2007. "Understanding and Applying the Concept of Community Disaster Resilience: A Capital-Based Approach." *Summer Academy for Social Vulnerability and Resilience Building*, January, 1–16.
Mazzei, Patricia. 2019. "Hunger and an 'Abandoned' Hospital: Puerto Rico Waits as Washington Bickers." *The New York Times*, April 7, 2019, sec. U.S. https://www.nytimes.com/2019/04/07/us/puerto-rico-trump-vieques.html.
McCarthy, J.J., O.F. Canziani, Neil Leary, D.J. Dokken, and K.S. White. 2001. "Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)." *Global Ecology & Biogeography* 12 (January): 87–88.

McConnell, Allan, and Lynn Drennan. 2006. “Mission Impossible? Planning and Preparing for Crisis1.” *Journal of Contingencies and Crisis Management* 14 (2): 59–70. https://doi.org/10.1111/j.1468-5973.2006.00482.x.

McCreight, Robert. 2010. “Resilience as a Goal and Standard in Emergency Management.” *Journal of Homeland Security and Emergency Management* 7 (1). https://doi.org/10.2202/1547-7355.1700.

Méndez-Nuñez, Carlos. 2018. “Puerto Ricans in Florida Still Dogged by Housing, Job Needs and More.” Orlandosentinel.Com. 2018. https://www.orlandosentinel.com/opinion/os-ed-puerto-rico-leader-speaks-out-for-evacuees-needs-20180105-story.html.

Mercer, Jessica, Ilan Kelman, Lorin Taranis, and Sandie Suchet-Pearson. 2010. “Framework for Integrating Indigenous and Scientific Knowledge for Disaster Risk Reduction.” *Disasters* 34 (1): 214–39. https://doi.org/10.1111/j.1467-7717.2009.01126.x.

Milliken, Jonny, and David Linton. 2015. “Prioritisation of Citizen-Centric Information for Disaster Response.” *Disasters* 40 (October): n/a-n/a. https://doi.org/10.1111/disa.12168.

Milman, Ollie. 2017. “Six Weeks after Hurricane Maria, Puerto Ricans Still Waiting for Help from Fema | World News | The Guardian.” The Guardian. 2017. https://www.theguardian.com/world/2017/nov/09/six-weeks-after-hurricane-maria-puerto-ricans-still-waiting-for-help-from-fema.

Molinari, Sarah. 2019. “Authenticating Loss and Contesting Recovery: FEMA and the Politics of Colonial Disaster Management.” In *Aftershocks of Disaster: Puerto Rico Before and After the Storm*. Chicago, IL: Haymarket Books.

Montoya, Lerman. 2018. “Puerto Rico’s Mountain Communities Cope with Hurricane Maria’s Aftermath.” *Cronkite News - Arizona PBS* (blog). May 13, 2018. https://cronkitenews.azpbs.org/2018/05/13/puerto-ricos-mountain-communities-cope-with-hurricane-marias-aftermath/.

Negroni, Lirio K., Catherine K. Medina, Marinilda Rivera Díaz, and Marissa Paniccia. 2020. “Perceptions of Mental Health and Utilization of Mental Health Services in Puerto Rico.” *Social Work in Mental Health* 18 (2): 149–69. https://doi.org/10.1080/15332985.2019.1700582.

Ngo Ehren B. 2001. “When Disasters and Age Collide: Reviewing Vulnerability of the Elderly.” *Natural Hazards Review* 2 (2): 80–89. https://doi.org/10.1061/(ASCE)1527-6988(2001)2:2(80).

Niles, Skye, and Santina Contreras. 2019. “Social Vulnerability and the Role of Puerto Rico’s Healthcare Workers after Hurricane Maria.” Natural Hazards Center. https://hazards.colorado.edu/quick-response-report/social-vulnerability-and-the-role-of-puerto-ricos-healthcare-workers-after-hurricane-maria.

Norris, Fran, Matthew Friedman, Patricia Watson, Christopher Byrne, Eolia Diaz, and Krys Kaniasty. 2002. “60000 Disaster Victims Speak: Part I. An Empirical Review of the Empirical Literature, 1981–2001.” *Psychiatry* 65 (February): 207–39. https://doi.org/10.1521/psyc.65.3.207.20173.

Norris, Fran H., Matthew J. Friedman, and Patricia J. Watson. 2002. “60,000 Disaster Victims Speak: Part II. Summary and Implications of the Disaster Mental Health Research.” *Psychiatry* 65 (3): 240–60. https://doi.org/10.1521/psyc.65.3.240.20169.

Norris, Fran H., Susan P. Stevens, Betty Pfefferbaum, Karen F. Wyche, and Rose L. Pfefferbaum. 2008. “Community Resilience as a Metaphor, Theory, Set of Capacities, and Strategy for Disaster Readiness.” *American Journal of Community Psychology* 41 (1–2): 127–50.

https://doi.org/10.1007/s10464-007-9156-6.
Orengo-Aguayo, Rosaura, Regan W. Stewart, Michael A. de Arellano, Joy Lynn Suárez-Kindy, and John Young. 2019. “Disaster Exposure and Mental Health Among Puerto Rican Youths After Hurricane Maria.” *JAMA Network Open* 2 (4): e192619–e192619. https://doi.org/10.1001/jamanetworkopen.2019.2619.
Ortiz-Blanes, Syra. 2020. “Opinion | Puerto Rico Se Levanta. Again.” *The New York Times*, January 14, 2020, sec. Opinion. https://www.nytimes.com/2020/01/14/opinion/puerto-rico-earthquake-power.html.
Palm, Risa, and Michael Hodgson. 1993. “Natural Hazards in Puerto Rico.” *Geosciences Faculty Publications*, January. https://scholarworks.gsu.edu/geosciences_facpub/6.
Pasch, Richard J., Andrew B. Penny, and Robbie Berg. 2019. “National Hurricane Center Tropical Cyclone Report: Hurricane Maria.” National Oceanic and Atmospheric Administration; National Weather Service.
Pelling, Mark. 2003. *The Vulnerability of Cities: Natural Disaster and Social Resilience*. 1 edition. London ; Sterling, VA: Earthscan Publications Ltd.
Pérez, Leda M., and Jacqueline Martinez. 2008. “Community Health Workers: Social Justice and Policy Advocates for Community Health and Well-Being.” *American Journal of Public Health* 98 (1): 11–14. https://doi.org/10.2105/AJPH.2006.100842.
Perry, Ronald. 2017. “Defining Disaster: An Evolving Concept.” In *Handbook of Disaster Research*, 2nd ed., 3–22. https://doi.org/10.1007/978-3-319-63254-4_1.
Phillips, Brenda D., and Morrow. 2007. “Social Science Research Needs: Focus on Vulnerable Populations, Forecasting, and Warnings.” *Natural Hazards Review* 8 (3): 61–68. https://doi.org/10.1061/(ASCE)1527-6988(2007)8:3(61).
Posada, Tomas Woodall. 2018. “How Grassroots Volunteer Organizations Are Mobilizing Communities in Puerto Rico.” Pulitzer Center. July 5, 2018. https://pulitzercenter.org/reporting/how-grassroots-volunteer-organizations-are-mobilizing-communities-puerto-rico.
Prowse, Martin. 2003. “Towards a Clearer Understanding of ‘Vulnerability’ in Relation to Chronic Poverty.” SSRN Scholarly Paper ID 1754445. Rochester, NY: Social Science Research Network. https://papers.ssrn.com/abstract=1754445.
Quarantelli, E. L. 2000. “Emergencies, Disasters and Catastrophes Are Different Phenomena.” http://udspace.udel.edu/handle/19716/674.
Resilient Puerto Rico Advisory Commission. 2018. “Reimagina Puerto Rico Report.”
Rios, Simon. 2017. “In Puerto Rico, Community Groups Transform Into Relief Brigades.” 2017. https://www.wbur.org/news/2017/10/20/puerto-rico-community-groups-relief.
Ripley, Amanda. 2009. *The Unthinkable: Who Survives When Disaster Strikes - and Why*. Reprint edition. New York: Harmony.
Robles, Frances. 2017. “Puerto Rico’s Health Care Is in Dire Condition, Three Weeks After Maria.” *The New York Times*, October 10, 2017, sec. U.S. https://www.nytimes.com/2017/10/10/us/puerto-rico-power-hospitals.html.
———. 2018. “FEMA Was Sorely Unprepared for Puerto Rico Hurricane, Report Says.” *The New York Times*, July 12, 2018, sec. U.S. https://www.nytimes.com/2018/07/12/us/fema-puerto-rico-maria.html.
Robles, Frances, and Luis Ferré-Sadurní. 2017. “Puerto Rico’s Agriculture and Farmers Decimated by Maria - The New York Times,” 2017. https://www.nytimes.com/2017/09/24/us/puerto-rico-hurricane-maria-agriculture-.html.

Robles, Frances, and Alejandra Rosa. 2019. "'The People Can't Take It Anymore': Puerto Rico Erupts in a Day of Protests." *The New York Times*, July 22, 2019, sec. U.S. https://www.nytimes.com/2019/07/22/us/puerto-rico-protests-politics.html.

Rodriguez, Carmen Heredia. 2018. "Dialysis Patients Are Still Trekking 12 Hours for Care After Hurricane Maria." The Atlantic. April 13, 2018. https://www.theatlantic.com/health/archive/2018/04/puerto-rico-dialysis-hurricane-maria/557741/.

Rodríguez, Havidán, William Donner, and Joseph Trainor, eds. 2018. *Handbook of Disaster Research*. 2nd ed. Handbooks of Sociology and Social Research. https://link.springer.com/book/10.1007%2F978-3-319-63254-4.

Rodríguez-Díaz, Carlos E. 2017. "Maria in Puerto Rico: Natural Disaster in a Colonial Archipelago." *American Journal of Public Health* 108 (1): 30–32. https://doi.org/10.2105/AJPH.2017.304198.

Román, Miguel O., Eleanor C. Stokes, Ranjay Shrestha, Zhuosen Wang, Lori Schultz, Edil A. Sepúlveda Carlo, Qingsong Sun, et al. 2019. "Satellite-Based Assessment of Electricity Restoration Efforts in Puerto Rico after Hurricane Maria." *PLOS ONE* 14 (6): e0218883. https://doi.org/10.1371/journal.pone.0218883.

Roure, Jodie G. 2019. "Immigrant Women, Domestic Violence, and Hurricanes Irma and Marìa in Puerto Rico: Compounding the Violence for the Most Vulnerable." 2019. https://www.law.georgetown.edu/gender-journal/in-print/volume-20-issue-3-symposium-2019/immigrant-women-domestic-violence-and-hurricanes-irma-and-maria-in-puerto-rico-compounding-the-violence-for-the-most-vulnerable/.

Sago, Renata. 2018. "For Older Puerto Ricans, Limited Housing Is a Barrier to Mainland Life Post-Hurricane Maria." *Marketplace* (blog). June 8, 2018. https://www.marketplace.org/2018/06/08/older-puerto-ricans-limited-housing-big-barrier-mainland-life-post-hurricane-maria/.

Salgado, Carmen D. Sanchez, and Alejandro J. Garcia Padilla. 2014. "State Plan on Aging Puerto Rico 2015-2018." Office of the Ombusman for the Elderly.

Santos-Burgoa, Carlos, John Sandberg, Erick Suárez, Ann Goldman-Hawes, Scott Zeger, Alejandra Garcia-Meza, Cynthia M. Pérez, et al. 2018. "Differential and Persistent Risk of Excess Mortality from Hurricane Maria in Puerto Rico: A Time-Series Analysis." *The Lancet Planetary Health* 2 (11): e478–88. https://doi.org/10.1016/S2542-5196(18)30209-2.

Scaramutti, Carolina, Christopher P. Salas-Wright, Saskia R. Vos, and Seth J. Schwartz. 2019. "The Mental Health Impact of Hurricane Maria on Puerto Ricans in Puerto Rico and Florida." *Disaster Medicine and Public Health Preparedness* 13 (1): 24–27. https://doi.org/10.1017/dmp.2018.151.

Schmidt, Samantha. 2018. "'Water Is Everything.' But for Many in Puerto Rico, It Is Still Scarce." Washington Post. 2018. https://www.washingtonpost.com/news/national/wp/2018/09/12/feature/water-is-everything-but-for-many-in-puerto-rico-it-is-still-scarce/.

Schoen, John W. 2017. "Here's How an Obscure Tax Change Sank Puerto Rico's Economy." 2017. https://www.cnbc.com/2017/09/26/heres-how-an-obscure-tax-change-sank-puerto-ricos-economy.html.

Segarra, Lisa Marie. 2017. "Hurricane Maria Made Landfall in Yabucoa, Puerto Rico." 2017. https://time.com/4949664/hurricane-maria-yabucoa-puerto-rico-map/.

Serlin, Christine. 2019. "Network Launched to Strengthen Puerto Rico Nonprofits." Housing Finance. February 5, 2019.

https://www.housingfinance.com/news/network-launched-to-strengthen-puerto-rico-non profits_o.
Silva, Daniella. 2018. “2,300 Puerto Rican Families Displaced by Hurricane Maria Are about to Lose Their Housing Assistance.” NBC News. 2018. https://www.nbcnews.com/storyline/puerto-rico-crisis/2-300-puerto-rican-families-displaced-hurricane-maria-are-about-n880356.
Sledge, Daniel, and Herschel F. Thomas. 2019. “From Disaster Response to Community Recovery: Nongovernmental Entities, Government, and Public Health.” *American Journal of Public Health* 109 (3): 437–44. https://doi.org/10.2105/AJPH.2018.304895.
Solnit, Rebecca. 2009. *A Paradise Built in Hell: The Extraordinary Communities That Arise in Disaster*. Viking Adult.
Spiekermann, Raphael, Stefan Kienberger, John Norton, Fernando Briones, and Juergen Weichselgartner. 2015. “The Disaster-Knowledge Matrix – Reframing and Evaluating the Knowledge Challenges in Disaster Risk Reduction.” *International Journal of Disaster Risk Reduction* 13 (September): 96–108. https://doi.org/10.1016/j.ijdrr.2015.05.002.
Stallings, Robert A., and E. L. Quarantelli. 1985. “Emergent Citizen Groups and Emergency Management.” *Public Administration Review* 45: 93–100.
Sullivan, Laura. 2018. “How Puerto Rico’s Debt Created A Perfect Storm Before The Storm.” NPR.Org. 2018. https://www.npr.org/2018/05/02/607032585/how-puerto-ricos-debt-created-a-perfect-storm-before-the-storm.
Sutter, John D., and Sergio Hernandez. 2018. “‘Exodus’ from Puerto Rico: A Visual Guide - CNN.” 2018. https://www.cnn.com/2018/02/21/us/puerto-rico-migration-data-invs/index.html.
Sutton-Grier, Ariana E., Kateryna Wowk, and Holly Bamford. 2015. “Future of Our Coasts: The Potential for Natural and Hybrid Infrastructure to Enhance the Resilience of Our Coastal Communities, Economies and Ecosystems.” *Environmental Science & Policy* 51 (August): 137–48. https://doi.org/10.1016/j.envsci.2015.04.006.
The New York Times. 2017. “Hurricane Maria Updates: In Puerto Rico, the Storm ‘Destroyed Us’ - The New York Times,” 2017. https://www.nytimes.com/2017/09/21/us/hurricane-maria-puerto-rico.html.
Tyler, Stephen, and Marcus Moench. 2012. “A Framework for Urban Climate Resilience.” *Climate and Development* 4 (4): 311–26. https://doi.org/10.1080/17565529.2012.745389.
U. S. Census Bureau. 2019. “U.S. Census Bureau QuickFacts: Puerto Rico.” 2019. https://www.census.gov/quickfacts/PR.
———. 2020. “American FactFinder.” 2020. https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.
UNDRR. 2017. “Terminology - UNDRR.” UN Office for Disaster Risk Reduction. https://www.unisdr.org/we/inform/terminology.
UNISDR, and UNOCHA. 2008. “Disaster Preparedness for Effective Response: Guidance and Indicator Package for Implementing Priority Five of the Hyogo Framework.” United Nations. https://www.undrr.org/publication/disaster-preparedness-effective-response-guidance-and-indicator-package-implementing.
U.S. Department of Homeland Security. 2015. “National Preparedness Goal.”
Varney, Sarah. 2018. “Listless And Lonely In Puerto Rico, Some Older Storm Survivors Consider Suicide.” NPR.Org. 2018. https://www.npr.org/sections/health-shots/2018/05/07/607761240/listless-and-lonely-in-puerto-rico-some-older-storm-survivors-consider-suicide.

Varney, Sarah, and Jason Kane. 2018. “Amid New Hurricane Season, Maria Still Taking a Toll on Puerto Rico’s Elderly.” PBS NewsHour. July 11, 2018. https://www.pbs.org/newshour/show/amid-new-hurricane-season-maria-still-taking-a-toll-on-puerto-ricos-elderly.

Vigaud-Walsh, Francisca. 2018. “Hurricane María’s Survivors: ‘Women’s Safety Was Not Prioritized.’” Refugees International. 2018. https://www.refugeesinternational.org/reports/2018/9/17/hurricane-maras-survivors-womens-safety-was-not-prioritized.

Viglucci, Andres. 2018. “Half of Puerto Rico’s Housing Was Built Illegally. Then Came Hurricane Maria.” Miamiherald. 2018. https://www.miamiherald.com/news/nation-world/world/americas/article199948699.html.

White, Gilbert F., Robert W. Kates, and Ian Burton. 2001. “Knowing Better and Losing Even More: The Use of Knowledge in Hazards Management.” *Global Environmental Change Part B: Environmental Hazards* 3 (3): 81–92. https://doi.org/10.1016/S1464-2867(01)00021-3.

Whittaker, Joshua, Blythe McLennan, and John Handmer. 2015. “A Review of Informal Volunteerism in Emergencies and Disasters: Definition, Opportunities and Challenges.” *International Journal of Disaster Risk Reduction* 13 (September): 358–68. https://doi.org/10.1016/j.ijdrr.2015.07.010.

Willison, Charley E., Phillip M. Singer, Melissa S. Creary, and Scott L. Greer. 2019. “Quantifying Inequities in US Federal Response to Hurricane Disaster in Texas and Florida Compared with Puerto Rico.” *BMJ Global Health* 4 (1): e001191. https://doi.org/10.1136/bmjgh-2018-001191.

Wisner, Ben, JC Gaillard, and Ilan Kelman. 2012. “Framing Disaster: Theories and Stories Seeking to Understand Hazards, Vulnerability and Risk.” In *The Routledge Handbook of Disaster Risk Reduction Including Climate Change Adaptation*, edited by Ilan Kelman, Jessica Mercer, J. C. Gaillard, Jessica Mercer, and J. C. Gaillard. Routledge. https://doi.org/10.4324/9781315684260.

Witmer, A, S D Seifer, L Finocchio, J Leslie, and E H O’Neil. 1995. “Community Health Workers: Integral Members of the Health Care Work Force.” *American Journal of Public Health* 85 (8_Pt_1): 1055–58. https://doi.org/10.2105/AJPH.85.8_Pt_1.1055.

Wyss, Jim. 2018a. “After Maria, the Threat Isn’t over for Puerto Rico’s Most Vulnerable — the Elderly.” Miamiherald. 2018. https://www.miamiherald.com/news/nation-world/national/article217793145.html.

———. 2018b. “Puerto Rico’s Suicide Rates Spiked after Maria. And the Mental Health Crisis Isn’t over.” Miamiherald. 2018. https://www.miamiherald.com/news/nation-world/national/article217545615.html.

Zhang, Dongsong, Lina Zhou, and Jay F. Nunamaker Jr. 2002. “A Knowledge Management Framework for the Support of Decision Making in Humanitarian Assistance/Disaster Relief.” *Knowledge and Information Systems* 4 (3): 370–85. https://doi.org/10.1007/s101150200012.